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THE LOCAL, OR HEAT, THUNDERSTORM.[1]

By CHARLES F. BROOKS.

[Clark University, Worcester, Mass.]

GROWTH AND DECAY OF A LOCAL THUNDERSTORM.

The development of a local thunderstorm from a clear or nearly clear sky proceeds by well-marked stages in the course of but a few hours. At first small bodies of air here and there are warmed more than those over surrounding areas, and as a result convection in small units occurs. The upward currents in the early morning when the air is still humid do not need to rise very high before cooling by expansion results in cloud formation. The sky becomes dotted with a number of small cumulus clouds at low elevation. As the heating continues the convectional to a great height and a large amount of condensation takes place within it. Up to a certain stage the upward current is sufficient to prevent any of the raindrops from falling out of the cloud. But when the load of accumulated rain becomes too great for some part of the rising current it breaks down and the first rain descends suddenly to the ground. As this rain falls it cools the air by evaporation, and, to some extent, the raindrops drag the air along with them, thereby establishing a descending current. This downward current spreads laterally at the ground and becomes the outblowing squall of the thunderstorm. Where this squall underruns the air that is

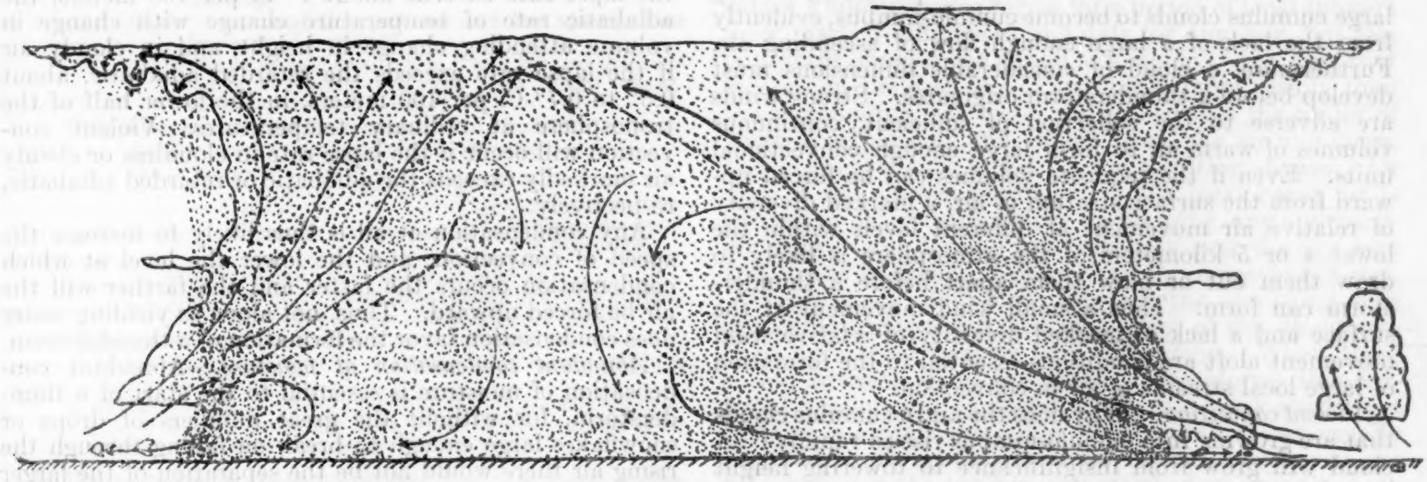

FIG. 1.—Idealized, diagrammatic, cross section of a well-developed local thunderstorm. The lines represent cloud outlines, the dots raindrops, the black spots hail-stones, and the arrows winds. The dotted line within the body of the cloud marks the boundary between ascending and descending winds and, therefore, roughly the position of the cloud base. It will be noted that winds may concentrate lines of falling raindrops in such a way as to bring more intense rainfall than is occurring by virtue of the precipitation falling from the same area at a height of a kilometer or two. The most intense rainfall is shown near the borders of the thunderstorm where there is most active condensation and release of the raindrops. With a given rate of fall from the thunderstorm or any part of it the amount of rainfall at any place passed over will increase in proportion to the decrease in the velocity of the storm. Thus, when a moderate or intense shower becomes stalled on a mountain slope a cloudburst occurs. A description with diagrams, of the details of the front of a thunderstorm was published in the MO. WEATHER REV. June, 1919, 47: 398-400.

currents become stronger. At the same time, however, the rise of temperature increases the depression of the dewpoint and, therefore, the height at which condensation will occur. When there is abundant moisture the increased strength of convection carries the convectional columns upward at a higher rate than that at which the level of condensation rises. On account of the greater heating and greater height to which convection must go, however, before a cloud will form only the larger columns can reach the cloud stage, so the clouds become larger and their number decreases. This process continues until there are great cumulus clouds interspersed by large clear spaces.

If the supply of warm air that is being displaced by colder air from aloft is sufficient and if the air at moderate heights is enough colder to make this warm air rise rapidly through an appreciable layer, the cumulus cloud grows rising in the periphery of the great cloud, a new, outward growing ring of cloud lower than the original cloud base is formed. (See lower projection on right of Figure 1.) Figure 1 shows the probable distribution of winds, hail, and rain and snow within a well-developed thunderstorm.

The physical make-up of the thunderstorms now changes from the simplicity of a central rising column of air surrounded by descending air to the complexity of a central descending and outflaring current of cold air, surrounded by a cone of rising warm air and still farther out by a zone of descending air, as at first. By the process of lateral expansion the thunderstorm may become so large that no more rain is carried to the center. Then the middle falls out, leaving a doughnut-shaped thunderstorm or a ringlike series of small thunderstorms attached to a common overflow sheet at the top. A moving thunderstorm develops a crescentic or half-

[1] Presented before American Meteorological Society, Washington, D. C., Apr. 26, 1922. Reference should be made to Prof. W. M. Davis's unexcelled description of local thunderstorms, in his *Elementary Meteorology*, Boston, 1894.

doughnut shape, representing the front half only, for it scoops up large masses of warm air in front, but has little except its own wake of cool air behind. Further expansion of these smaller units may now be limited by the coolness produced by neighboring storms, and so with the life-giving warm air exhausted, the storms wane and the clouds evaporate.[2]

CAUSES OF LOCAL THUNDERSTORMS.

A thunderstorm is the result of relatively large streams of air in violent convection attended by abundant condensation of moisture. Even in the smallest of local thunderstorms the air volumes involved amount to many cubic kilometers. The maximum strength of the upward movement of air within any thunderstorm must be considerable, for the electrical separation which causes the lightning is probably the result of the splitting of raindrops (or snowflakes) and the rapid carrying aloft of the smaller, negatively charged fragments while the larger, positively charged ones descend. That abundant condensation of moisture is an essential feature of a thunderstorm is evident from the invariably attendant great mass of cloud and the usually accompanying intense rainfall.

Large local streams of air in convection.—Any observer of clouds has noticed the failure of promising-looking large cumulus clouds to become cumulo-nimbus, evidently from the lack of a large enough flow of ascending air. Furthermore, a cloud of considerable dimensions must develop before a thunderstorm originates. Strong winds are adverse to the collection of sufficient, continuous volumes of warm air to form large enough convectional units. Even if the requisite volumes can be forced upward from the surface stratum of air, a marked diversity of relative air movement at different levels within the lower 4 or 5 kilometers of the atmosphere is likely to draw them out or blow them apart before a thunderstorm can form. Thus a small wind movement at the surface and a lack of marked diversity of relative wind movement aloft are conditions essential to the formation of large local streams of air in convection.

Violent convection.—Why does the air in cumulus clouds that are growing into cumulo-nimbus rise so rapidly? A cloud will grow from insignificance to towering height in only a few minutes. On different occasions rough, angular measurements of mine have shown upward motions of 3, 4, and 7 meters per second in such tops. In addition, the sides of such cumuli bulge perhaps half as fast as the top rises. It is evident that the upward current within the cloud must be more rapid than the rise of its summit. After the thunderstorm is formed, the occurrence of enormous drops of rain and the occasional fall of hail of appreciable size indicates the presence of great uprushes of air within the cloud. Furthermore, such unfortunate aviators and aeronauts as have been inside active portions of cumulo-nimbus clouds have experienced great bumpiness owing to the strong up-and-down currents.[3]

[2] In an article on "Clouds in east Texas, June 8, 1918" (Mo. WEATHER REV., March 1919, 47: 151–154), I have described in some detail the development and decay of cumulus clouds and local thunderstorms. The characteristics there described are typical of local weather in many parts of the United States under similar conditions of generally clear upper air with warm, moist lower air.

[3] See Mo. WEATHER REV., August, 1919, 47: 523–532.

The degree and volume of upward motion within a growing cumulus or cumulo-nimbus cloud could be observed and computed. A corps of observers with plenty of pilot balloons, theodolites, and base lines could obtain data as to the amount of air per minute inflowing under the cloud base, and by successive angular measurements of the upward and lateral expansion of the cloud could provide themselves with a check on the computation of inflow. The actual upward speeds would be indicated to some extent by the rate of rise of balloons entering the cloud base at different points, thus providing a way for distributing the total upflow as computed from the inflow and the area of the cloud base. In making the computations of the upward motion of the air the increase in the volume on account of expansion would not be neglected.

Violent convection is caused by the instability accompanying a large lapse rate in temperature.[4] A large lapse rate may be caused by heating below, cooling above, or both. The formation of a relatively hot, surface stratum in the early afternoon is favored by (1) a lack of clouds, (2) dry ground, (3) a small lapse rate to 2 or 3 kilometers, which prevents convection from sending up the surface air till it becomes very warm, and (4) a high, morning minimum temperature, induced, perhaps, by nocturnal cloudiness. The occurrence of relatively cold air aloft is favored by (1) cloudy weather for some days, (2) northerly wind (in Northern Hemisphere) recently begun or a southwesterly wind which has continued for some time,[5] and (3) either a lack of upper clouds, resulting in cooling by radiation, or the presence of heavy cirrus with the lower ends of its snow trails cooling the air by evaporation. The part played by the falling, dense clouds of snow from the top sheets of old thunderstorms is often a highly important one. This snow by melting and evaporating not only keeps cold the air down to an altitude of about 3 kilometers, but also adds considerable moisture to it. Thus the drifting, old tops of thunderstorms help to provide conditions favorable for thunderstorms in the districts they invade. Convection will take place in cloudless air if the lapse rate exceeds about 1° C. per 100 meters, the adiabatic rate of temperature change with change in volume attending change in height, and in cloudy air if the lapse rate exceeds the retarded adiabatic, about 0.5° to 0.7° C. per 100 meters, in the lower half of the troposphere at ordinary temperatures. Violent convection will occur if the lapse rate in cloudless or cloudy air markedly exceeds the adiabatic or retarded adiabatic, respectively.

Any condensation at all is thus likely to increase the speed of convection; and the lower the level at which condensation occurs the faster and the farther will the air be forced upward. Thus, not alone as yielding water does condensation favor the formation of a thunderstorm.

Abundant condensation of moisture.—Abundant condensation of moisture is essential to the start of a thunderstorm, for without the great numbers of drops or snowflakes large enough to break on falling through the rising air there would not be the separation of the larger from the smaller fragments which seems to be necessary to the production of lightning. Abundant condensation is also necessary to the maintenance of the mechanical strength of a thunderstorm. The falling rain evaporates and keeps cool the air descending with it. Without its cold element coming to the ground, where it can run under and force upward the warm element, the power which the thunderstorm derives from being a self-cooling heat engine could not arise. Plenty of moist air is, therefore, needed in the production and maintenance of a thunderstorm. A high moisture percentage (e. g., 2 or 3 per cent) in the surface air, even if it prevails through a layer a kilometer thick, will not be sufficient if the air aloft is dry, for the early convection rapidly dissipates this moisture by mixing the moist air with the dry air above. Thus, the moist layer should extend up to 2 or 3 kilometers, at least, to insure it against loss of effectiveness before convection can form a thunderstorm. A wind blowing for several days from a warm source of moisture, with attendant daytime convection to spread the moisture through an appreciable vertical layer, is,

[4] "Lapse rate" is being used as a substitute for the cumbersome "rate of vertical decrease" or "vertical temperature gradient."

[5] Cf. H. W. Clough, The sequence of changes in wind direction, pressure, and temperature in the free air (synopsis in), Bull. Am. Metl. Soc., July, 1922.

therefore, usually a necessary precedent to thunderstorm formation.[6]

Local indications of conditions favorable for local thunderstorms.—Since there are three essentials to the formation of thunderstorms—plenty of warm air, rapid ascent, and much moisture—taking each of these elements separately into account simplifies the difficulty of attempting to consider all the factors at once in predicting whether or not local thunderstorms will occur. One, or even two, of the factors may be very favorable to the formation of thunderstorms, while another may be adverse. Under such conditions local thunderstorms do not occur. The following outline questionnaire may be helpful in showing the complexity of any attempt at forecasting local thunderstorms even only six hours in advance and in providing a guide to making predictions of afternoon, heavy, local showers:

QUESTIONNAIRE FOR PREDICTING LOCAL THUNDERSTORMS.

A. Will large units of warm air become available?
  1. Will the wind this afternoon be light? and
  2. Will there be a lack of marked diversity of relative air movement up to 4 or 5 km.?

B. Will there be violent convection?
  1. Will the air at the surface become hot relative to that aloft?
     (*a*) Will there be a lack of cloud sheets most of the morning?
     (*b*) Is the ground dry (dryness and low specific heat favors rapid heating)?
     (*c*) Is the lapse rate small up to 2 or 3 km. (so that considerable heating will take place before convectional overturning occurs)?
  2. Is there, or will there be, relatively cold air aloft?
     (*a*) Has the weather been cloudy for some days?
     (*b*) Is the wind at 3 or 4 km.
        Northerly, since only recently? or
        Southerly, since some time ago?
        } For Southern Hemisphere use opposite directions.
     (*c*) Was the night free of upper clouds? or
        Has there been appreciable cooling of the air at these levels by evaporation of heavy cirrus trails?

C. Will there be abundant condensation of moisture?
  1. Is the surface air moist (i. e., with high absolute and high relative humidity)?
  2. Is there, or will there be, a plentiful supply of moist air up to 2 or 3 km., the height from which return currents of air can come before a thunderstorm can form?

If the answers to these questions are tabulated somewhat as follows, their indications may be readily summarized:

PROBABLE CONDITIONS AT NOON OR 2 P. M. (DETERMINED AT 8 A. M.).

Date.	Large streams of air.		Violent convection.		Abundant condensation.	
	Light wind.	Lack of diversity aloft.	Large lapse rate because—		High absolute and relative humidity.	Moist up to 2 or 3 km.
			Hot at surface.	Cold aloft.		

Under each of the six headings a plus, a zero, or a minus may be used to indicate answers of "yes," "moderately so," or "no," respectively. A minus in any column will show a probability of no local thunderstorms. Furthermore, at least one plus under each of the principal three headings will indicate that local thunderstorms are probable, while 5 or 6 plusses will show that thunderstorms are to be expected and that they will probably be violent.

WHERE THE LOCAL THUNDERSTORMS ORIGINATE.

Local thunderstorms tend to originate most often where large volumes of moist air are readily warmed and forced upward, e. g., broad expanses of meadowland or river flats, and over cities,[7] hills, and mountains. From places of origin the storms grow laterally and move forward. As lateral growth largely depends on local supplies of hot air, and as the general winds about the body of a thunderstorm are usually fairly constant in direction, it follows that the frequency of thunderstorms rains must be markedly different within even a relatively small area, such as a State, or even a county.[8] Within a homogeneous area, however, the wetting of strips by local showers temporarily makes the dry strips the loci of thunderstorm formation. At College Station, Tex., during a rainy week in the latter part of August, 1918, this phenomenon was noted very clearly, and local forecasts of thunderstorm rains were successfully based on the widths and position of strips wet by thunderstorms on the preceding day. Daily rainfall statistics for stations within a homogeneous region for a period of local showers show marked differences in totals for any day, but less important ones for the period as a whole. Any area that escapes on the first day or two heats more readily than the surrounding wet areas, and so becomes the center of greatest expansion and inflow from the surroundings, and in consequence is wet by the resulting shower. Or even if the shower produced by the local rising air is carried to other fields before discharging, any approaching shower will develop most strongly over the dry area and therefore drench it more than those previously wet.

When winds aloft blow forward, the spreading tops of local thunderstorms, the first effect of this cloudiness is to curb local heating and convection. When these sheets advance along the paths of the storms this curtailed heating and convection starves a weak storm, yet sustains a strong one. The small, weak storm usually needs strongly heated, local air masses, which can not be supplied if the top has cast its shadow over the path of the storm. Thus, it dies, and a considerable strip in advance of it remains dry for the day. The strong storm, on the contrary, is favored by the lack of local convection in its path, for the warm surface air has not been dissipated by small scale convection nor cooled and dried by local thunderstorms. The advancing plow of cold air scoops up a good supply of warm air for miles and miles, and the storm thunders across the countryside with undiminished energy, the same distance as the edge of the thunderstorm top. Once such heights are known it becomes necessary only to determine the actual speed of winds at the intermediate levels. This speed is readily found from the angular motion of alto-cumulus or alto-stratus clouds considered in conjunction with the height of such clouds as found from the cumulus measuring stick. By taking the measured height and the angular height the distance is obtained, and from the speed the time required to traverse this distance is found.

When the thunderstorm is near at hand the rate of increase in the angular elevation of any prominent

[6] For a detailed discussion of the physics of the thunderstorm, see W. J. Humphreys's *Physics of the Air*, Philadelphia, 1920.

[7] See R. E. Horton, Thunderstorm-breeding spots and The beginning of a thunderstorm, MO. WEATHER REV., April, 1921, 49: 193–194.

[8] A preliminary study of thunderstorm data collected by W. H. Alexander from about 1,000 observers in Ohio in 1917 strongly supports this general statement even for a region as homogeneous as Ohio.

portion of the cloud or the rate at which the interval between the thunder and lightning decreases may be used to determine the speed. The distance in miles when the thunderstorm is within hearing is very nearly the number of seconds between a flash of lightning and its subsequent thunder divided by five.

CONCLUSION.

The visible development of the local thunderstorm, its compactness, the power of its self-contained action, the grandeur of its towering cloud masses, and its commanding flashes of lightning and peals of thunder attach to it an unique interest, especially to meteorologists, who see in the thunderstorm a wide range of atmospheric phenomena easily observed.

DISCUSSION.

In connection with the part played by a cold layer of air aloft, H. H. Clayton showed how local convection might proceed in an ordinary manner in the layer of air below the cold one, until reaching the base of the layer in which the gradient was adiabatic. Then rapid ascent of cloud tops would take place and thunderstorms probably result. The occurrence of a cold stratum of this nature is often indicated by turreted alto-cumulus clouds formed by convection taking place independently within cold layer.[9] C. F. Brooks called attention to the occurrence of columnar or turreted cumulus when local convectional columns entered such a layer.

[9] Cf. T. R. Reed, Some observations of a bombing pilot in France, Mo. WEATHER REV., April, 1920, 48: 216-217.

THE TOPOGRAPHIC THUNDERSTORM.[1]

By CLEVE HALLENBECK.

[Weather Bureau Office, Roswell, N. Mex., June, 1922.]

It would seem that nothing new could be added to the voluminous literature of the thunderstorm, but in all discussions of this phenomenon that have come to our notice the influence of topographic features in modifying and in actually producing thunderstorms has been neglected, presumably for the reason that meteorologists who have directed their attention to the thunderstorm have studied it in regions where the topographic factor was negligible.

One type of cyclonic thunderstorm is generated by the underrunning of humid air by a colder current; in fact, the strictly underrunning current produces more thunderstorms than it usually is credited with. It seems reasonable to assume, therefore, even in the absence of supporting data, that when instead of the underrunning stream of cold air we have a long, comparatively steep slope facing the direction of the rain-bearing winds, condensation and consequent convection may occur in an upslope flow of air.

Such a slope is found immediately west of the Pecos River in New Mexico. The ground rises a vertical distance of 1,460 meters through a horizontal distance of 113 kilometers, a rise of about 13 meters per kilometer (69 feet per mile). The valley as a whole has a southward grade of 2 meters per kilometer (11 feet per mile), so that the steepest slope is east-southeast to west-northwest, thus exactly facing the direction of the moisture-bearing winds. In this direction the rise from river to crest is over 1,500 meters, and air moving up this slope would be subjected to a mechanical cooling of about 14° C. This is about 2° less than the normal depression of the dew point at Roswell on summer afternoons. But in the case of an easterly or southeasterly wind of a general circulation, and which in the Pecos Valley is emphatically the rain-bearing wind, the depression of the dew point is much less than normal, frequently no more than 5° or 6° at midday; consequently condensation normally occurs in an upslope wind of a general circulation. Also on midsummer mornings the depression of the dew point usually is no more than 4°, and an upslope wind during the early morning hours, whether local or of a general circulation, is attended by condensation over the west slope in the form of an irregular belt of cumuli or strato-cumuli (most frequently the former) paralleling the valley, and which varies in dimensions from a row of small, detached cumuli to an unbroken, greatly elongated thunderstorm. Such a thunderstorm, observed at 6 a. m., August 16, 1921, was about 50 kilometers distant and subtended an angle of 70°, which gave it the remarkable length (or width, strictly speaking) of nearly 70 kilometers (42 miles).

It is assumed by many that condensation caused by the mechanical cooling of an upslope wind is in the form of fog or low stratus cloud. Such rarely occurs in this district, even in winter, presumably on account of the overrunning of the lower air by the upslope flow and the decreasing depression of the dew point with increase of elevation above the ground, whereby condensation in an upslope wind usually begins at a considerable elevation.

While condensation normally occurs in air of a general circulation moving up the west slope of the valley, it is delayed until the wind has persisted long enough to import moisture a distance of 500 to 1,000 kilometers. An exception to this rule obtains when there has been general precipitation over eastern New Mexico, following which the air for a day or two is humid enough for condensation to occur promptly in an upslope wind of whatever character.

It has been observed that thunderstorms, which form over the west slope under the conditions stated, nearly always move down grade in a direction more or less opposed to that of the prevailing wind. This clearly is due to gravity. A considerable mass of air under the storm cloud is cooled much below the temperature of the surrounding air, and starts downhill, plowing its way through the opposing flow of warm, humid air, part of which is deflected upward and part turned to one or both sides. That deflected upward corresponds to the rising inflow on the front of the "heat" thunderstorm. The reversal in direction, whereby the rear of the storm becomes the front, evidently occurs soon after precipitation begins, for while thunderstorms sometimes pass over or near Roswell moving west, none has ever been observed to form on the west slope and move westward. However, since the average distance at which these storms form west of the station is 40 or 50 kilometers, an upslope movement of a few kilometers probably could not be detected from the station.

The storm now becomes somewhat analogous to one type of cyclonic thunderstorm, except that the colder underrunning stream of air is quite limited as to length and is moving under the influence of gravity rather than of a pressure gradient. (Strictly speaking, it is a pressure gradient in each case.)

[1] Presented at the meeting of the American Meteorological Society at Salt Lake City, Utah, June 22, 1922.

During its progress down the slope this air is subjected to mechanical heating, but moving at the rate of 30 kilometers per hour, which is not far from the average velocity of the thunderstorm, this heating would amount to but 3° C. per hour (for dry air) and is doubtless more than counteracted by the continued cooling effect of evaporation, etc. Consequently the arrival of the storm in the lower valley is attended by an abrupt fall in temperature of 10° to 16° C. or more. An extreme fall of 20.5° C. is of record.

It would be assumed that since the storm in its downward course encounters a progressive increase in the depression of the dewpoint, it would gradually weaken and finally die. This is what happens to a great majority of the storms of this type. Few of them deliver as much as 0.6 centimeters (0.25 inch) of precipitation at the lower valley stations; nearly half of such as reach Roswell deliver no more than a trace, and many of them break up before reaching the lower valley. Yet they frequently present a majestic and awe-inspiring front when they first start on the downward path that leads to their dissolution, and the deception practiced on newcomers by this type of storm is a standing jest among the initiated. In August, 1921, for example, 19 thunderstorms yielded a total of but 1.9 centimeters (0.77 inch) of rain. Consequently, while these storms are of frequent occurrence, and yield abundant precipitation over the upper, uncultivated portion of the west slope, they are nearly negligible so far as the farming belt of the lower valley is concerned.

The circulation in a typical storm of this class is essentially that which would be expected of a mass of cold air flowing down a slope through an opposing upslope movement. It is not known how much of the opposing warmer air is deflected aloft, but part of it certainly is turned to one or both sides; the former when there is a considerable angle between the opposing currents, and the latter when they are meeting approximately "head-on." There is thus a circulation around a vertical axis on one or both sides the underrunning mass—when on but one side this horizontal circulation appears to be the predominating feature of the air movement near the ground, but no similar circulation has ever been observed with certainty at the cloud level. It seems, therefore, that the underrunning stream of air is being spread out and scattered on its front, and constantly renewed on its rear, as long as the storm continues.

During 1918 and 1919 observations of horizontal wind direction attending the passage of thunderstorms were made at two points in addition to the automatic record at the Weather Bureau station, the three points being in a nearly straight line, separated by intervals of nearly 2.5 kilometers. Only thunderstorms traveling approximately normal to this line and including at least two of the three points of observation in its path were considered. Of the 113 thunderstorms recorded at Roswell during the two years only 14 entirely conformed to these conditions; nevertheless some interesting data were secured. The probable horizontal circulation near the surface of the ground is shown in Figure 1 for three of these storms. The short arrows along the lines A–A and B–B are the observed directions at five-minute intervals. The long arrows indicate the interpolated directions. Entire accuracy is not claimed for these assumed circulations, as any one of them could have changed materially while passing over the points of observation. It is believed, however, that they are approximately correct, as it would be difficult to construct any other rational system of purely horizontal wind that would conform to the observed data: It also is generally known that at a comparatively short distance each side of a thunderstorm the prevailing flow of air is not materially disturbed.

The first of the three charts shows a well-developed circulation about a vertical axis on each side the central stream of cooled air. From this chart the idealized circulation in this type of storm could easily be visualized.

In the second, one of the gyratory circulations is greatly predominant; the secondary one may be either just forming or dying out. In the third, only one circulation appears, although there may have been a secondary one to the left, outside the storm's path.

In each case, the circulation as a whole has a progressive movement from right to left approximately opposite to the direction of the prevailing flow of air. The dotted lines represent the front of the precipitation.

It seems to the writer that some form of horizontal circulation must be assumed for most thunderstorms, since the front of the underrunning stream—the "thunderstorm gust" or "squall wind," as it often is misnamed—has a velocity considerably greater than that of the storm as a whole; nevertheless it never outruns the front of the storm more than a few minutes; it lags behind as often as it outruns. At Roswell its maximum velocity averages twice the velocity of the storm; it can not, therefore, be a straight horizontal wind.

It will be understood that we are speaking only of typical storms of this class. Many thunderstorms occurring in this district are hybrid and can not be classified positively under any head. In some the air circulation is very chaotic. The changes in wind direction in a severe hailstorm of April 25, 1919, were recorded at three points in the storm's path, the observation points being in a nearly straight line approximately normal to the path of the storm, and no system of purely horizontal winds could be reconciled to the observed data, although the storm belonged to the topographically generated class.

It frequently has been observed that in their course down the slope the storms follow a curved path; due probably to the deflecting effect of the prevailing wind. They may curve either to the right or left. The hailstorm above referred to blazed an enormous question mark through the farming district, thus adding insult to injury, as it were.

It may be interesting to note that often, when the thunderstorm breaks up before reaching the lower part of the valley, its cool stream of underrunning air continues on its way, and, if it passes over the Weather Bureau station, leaves its record in the form of a sudden fall in temperature accompanying an abrupt change in wind direction and velocity. There are instances where this air reached the station more than an hour after the storm had broken up. The writer recalls one instance when the meteorologist in charge of the Lander (Wyo.) station was his guest at a Saturday-afternoon ball game, during which there came a sudden, cool wind out of the southwest which raised sufficient dust to temporarily suspend the game. The visitor peered out in all directions to discover the impending thunderstorm, and found nothing but a few tattered clouds in the southwest—the only visible remnant of a thunderstorm that had been making its way down the slope two hours earlier. An explanation was requested and furnished.

This cooled air is, of course, warmed after the storm has ceased, and the fall of temperature attending its arrival in the lower valley is not large—usually 3° to 8° C. Nine of these "phantom thunderstorms" occurred at Roswell in 1916 and eleven in 1917; all were apparently traceable to thunderstorms that had broken up and disappeared.

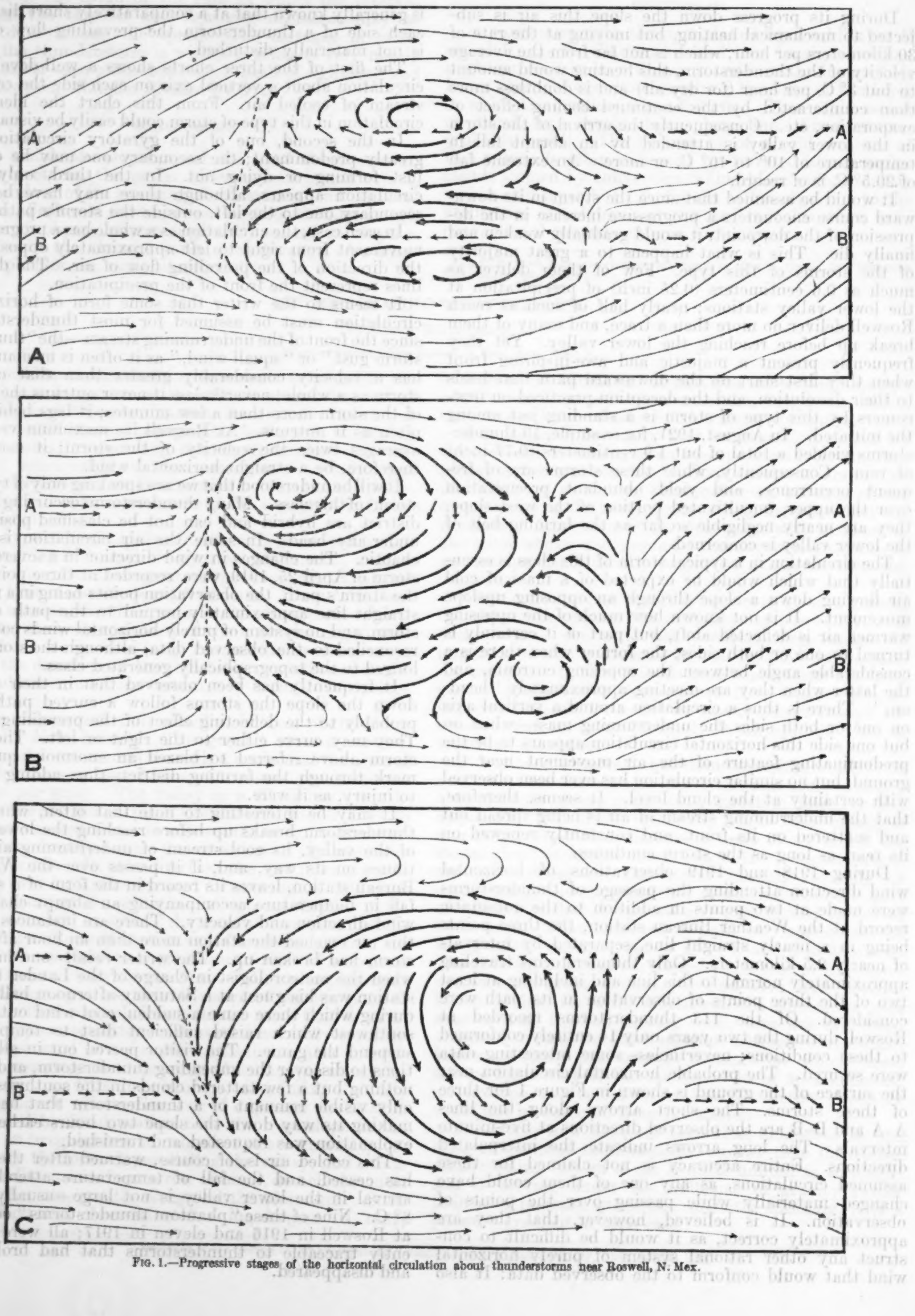

FIG. 1.—Progressive stages of the horizontal circulation about thunderstorms near Roswell, N. Mex.

It may be argued that this so-called topographic thunderstorm may really be of the "heat" variety, since any thunderstorm, however generated, would tend to gravitate down hill. Possibly some that we have classed as topographic were really "heat" storms. But since approximately 80 per cent of all thunderstorms observed at Roswell form on the west slope in an upslope wind, it is certain that this slope is a vital factor in their genesis. Also, both the number of thunderstorms and the total precipitation therefrom increase with increase of elevation westward from Roswell.

A second type of topographically generated thunderstorm occurs in the Pecos Valley, and is decidedly the most interesting phenomenon the writer ever has observed. Its most marked characteristics are as follows: (1) It invariably moves directly up the valley (south to north); (2) it usually occurs at night; (3) two, three, or more such storms sometimes travel in file; (4) there is a stratum of low cloud, nearly always continuous, *below* the thunderstorm circulation; (5) the wind at the Weather Bureau station shows no material change in direction or velocity.

Air moving directly up the Pecos Valley has, at Roswell, an elevation of 1,100 meters above its starting point on the Gulf coast. Reference is made to the Gulf of Mexico because it is only when moisture is imported directly from there that the type of storm under discussion occurs. The air has, therefore, been subjected to a mechanical cooling of about 10° C. The fact that such thunderstorms occur mostly at night may be due to additional cooling by radiation and to the development of an underrunning flow in the form of air drainage.

There seldom is any material change in the velocity of the wind immediately before, during, or immediately after this storm, and its direction is usually southerly at the start, shifting to northerly at some time during the rain; this shift clearly is due to the cooling of the air, whereby it starts to flow down the valley. The direction, however, may be from any point of the compass. The thunderstorm itself is completely hidden from view by an intervening screen of low cloud; this screen covers the entire visible sky, and moves smoothly northward. The storms can be followed only by their thunder and precipitation, but many of them seem to outrun the lower cloud screen. Literally, this is a thunderstorm "above the clouds."

Often two such storms move in file; several cases of three following closely in file are on record (one case occurred while this paper was being prepared, on May 14, 1922), and on June 4, 1921, four thunderstorms followed so closely on each other's heels that the thunder of one had not died away in the north before the rumbling of the next was audible in the south. All were completely screened from view, but the middle of their path apparently was along the river.

On April 15–16, 1915, there occurred a thunderstorm of this type which evidently was composed of five, or possibly six, initially individual thunderstorms that had coalesced into one. The originally distinct storms could be distinguished only by the rise and fall in the volume and frequency of thunder and the contemporaneous increase and decrease in the rate of precipitation. In fact, practically every stage of development has been observed, from two or more separate storms moving in file to a single greatly overgrown thunderstorm in which the original units could no longer be distinguished.

A thunderstorm which delivers excessive precipitation over an area 270 kilometers long and 115 kilometers wide, an area nearly equal to Massachusetts and Connecticut combined, with lightning and thunder lasting nearly ten hours, is a sizable thunderstorm for an arid region, yet the storm of April, 1915, fitted these dimensions. And at that it was not the largest thunderstorm that has occurred in the Pecos Valley.

The following explanation of the formation of this type of storm is offered: The upvalley flow of air—very humid, as it came from the Gulf of Mexico—is cooled mechanically to its dew point simultaneously, or nearly so, at widely separated points. Since the valley slope is but 2 meters per kilometer (11 feet per mile) a difference of 1° in the dew point of two parts of the upflowing air would mean a distance of more than 50 kilometers between the points at which condensation would begin. Unless the dew point were remarkably uniform throughout, condensation would occur at different elevations. There would therefore be a series of local condensation areas, and, consequently, a series of convections moving in file. With continued progress up the valley, with the consequent additional cooling, the areas of condensation would spread, and would eventually join each other, forming one continuous sheet of cloud. The individual convections arising from the upper portions of this cloud also would grow, but it is probable that each maintains its integrity to some extent, for a single convection covering 25,000 square kilometers is unthinkable.

It is further apparent that a final stage in the life of this storm is the total cessation of convection, or, at least, the total cessation of lightning and thunder, although preciptation may continue for some time at a heavy and even excessive rate. An example of this occurred on August 7–8, 1916, which delivered over 13 centimeters (5.5 inches) at both Roswell and Carlsbad, 120 kilometers apart. This storm was attended by lightning and thunder at Carlsbad (the lower of the two points) but not at Roswell, although at the latter point it delivered excessive precipitation for nearly two and a half hours without a break.

While such storms are infrequent, they always yield heavy precipitation, and are responsible for most of the floods that have occurred in the Pecos and its tributaries.

Some objection may arise to the idea of a thunderstorm occurring "above the clouds," but the writer has been assembling his data for six years and is sure of his position in this. An invisible thunderstorm, which approaches and passes overhead, with no movement of the leaves on the trees other than that produced by the falling rain, would certainly be a novelty in districts where every thunderstorm is attended by a high or violent wind. Only one such case has been observed here but as a rule the wind is light. Sometimes the thunderstorm circulation apparently affects the lower air, but these are exceptions to the rule.

There is no reason why a thunderstorm may not develop and run its course wholly removed from the surface of the earth. A convection can, theoretically, start at almost any elevation above the surface. The fact that nearly all thunderstorms are based on the ground is due to the fact that most convections start from the ground.

It has been noted that when such widespread thunderstorms as have been described occur in the Pecos Valley, similar storms occur at the same time in the Canadian Valley in the northeastern part of the State—similar, at least, as regards the amount and extent of precipitation. Possibly both types of thunderstorms discussed herein may be observed in other districts of the West where a long slope is presented to the direction of the moisture-bearing wind.

TROPICAL CYCLONES IN AUSTRALIA AND THE SOUTH PACIFIC AND INDIAN OCEANS.

By STEPHEN SARGENT VISHER, Ph. D.

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The tropical cyclones of the West Indian region, the Far East and the Bay of Bengal are fairly well known. The inadequacy of published information as to similar storms in other parts of the tropics is perhaps well recognized and it may be necessary at times to deal with assumptions, as witness the following: A recent writer, somewhat of a specialist on Pacific storms, felt able only to surmise as to the monthly distribution of hurricanes in the south Pacific.[1]

With the aid of grants from Yale and Indiana Universities, and the Bishop Museum of Honolulu, the writer has gathered information as to tropical disturbances and their effects. Several island groups were visited in the Pacific and much information was also obtained in Australia and in the Far East. Conferences were had with Father Algué of Manila, Father Froc of Zi-ka-wei, Shanghai, and with Directors Okada of the Japanese Imperial Marine Observatory, Kobe, and Claxton of the Royal Observatory, Hongkong. Published and unpublished information has been gathered from many sources, including foreign and domestic libraries. A bulletin has been prepared on "Australian hurricanes and related storms with an appendix on hurricanes in the South Pacific," which is to be published soon by the Australian Commonwealth Bureau of Meteorology. In it over 500 hurricanes are listed with concise information about each; tracks of 200 hurricanes affecting Australia are traced and somewhat extensive studies are made of the distribution and characteristics of hurricanes in and near Australia, and in the south Pacific. In the following pages some of the material in this bulletin is summarized and numerous facts not appropriately included there are added, especially as to the storminess in the south Indian Ocean.

Tropical cyclones, there commonly called hurricanes, have been recorded in every month of the year in the south Pacific, in all but August in Australia, and in all but August and September in the south Indian Ocean. However, they are rare from May to October, and not common in November or April. The hurricane season for most of the region is the four-month period December to March inclusive, but there is considerable variation as to the stormiest month, as will appear later.

As to the frequency of storms: Two serious questions arise, first, the incompleteness of the records and second, as to what severity of storm is required in order to have it merit inclusion. Information is very scanty in respect to most of the region, for most years. In order to arrive at an estimate of the total frequency which will not be woefully inadequate, it seems necessary to consider only the periods for which fairly full records are available. Also it seems wise to do as Froc and Algué[2] have done, include all well-developed tropical cyclones even if winds of hurricane force are not rcorded, for as they remark, it is not known how soon such a storm will develop into a destructive typhoon, or whether or not it was destructive along part of its little known course.

After making conservative allowance for the incompleteness of the record, and counting all gale-producing storms, not only true hurricanes, it appears probable that on the average fully a dozen tropical cyclones occur annually in the 60° of the south Pacific west of the Low or Taumotu Archipelago (long. 140° W.), about as many in the 60° of longitude which includes Australia (100° to 160° E.) and probably somewhat more than a dozen in the 60° of the south Indian Ocean between Africa and the Australian coastal waters (long. 40° to 100° E.). The evidence for these conclusions is given in some detail beyond. Hence, the indications are that about as many tropical cyclonic storms occur annually in this half of the southern Tropics (longitudes 40° E. to 140° W.) as one recent authority reports from the chief storm areas of the Northern Hemisphere (34 storms a year, including many which do not attain hurricane force.)[3]

Now to take up the storminess of the three great parts of the Southern Hemisphere treated in this article. The storminess of the South Pacific will be considered first. The occurrence by island groups and the monthly distribution of tropical hurricanes in the South Pacific from New Caledonia to the Low or Taumotu Archipelago inclusive is considered in Table 1. It is based on a total of 246 hurricanes, but as some storms affected more than one group, the sum of the monthly figures totals 292.

TABLE 1.—*Tropical cyclones in the south Pacific, longitudes 160° E. to 140° W., by island groups.*

	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Total number of recorded storms.	Indicated average annual frequency.
Fiji	21	15	20	4							1	13	74	2
Tonga	16	7	14	6	1						3	3	50	2
Samoa	10	2	8	2							1	6	29	2-3
North Hebrides	11	9	9	2	1					1	3	1	37	2
North Caledonia	11	11	10				1		1	2		4	40	3
Norfolk	4	7	7	2		2		1		2			25	2
Pautomas	3	2	1						1				7	.5
Tahiti	3	1							1			3	8	.2
Solomons	2	1	2									1	6	.2
Cook Islands	2	5	2	2								5	16	.5
Totals	83	60	73	18	2	2	1	1	3	5	8	36	292	

It will be seen by Table 1 that the hurricane season extends from December to April, inclusive. During this five-month period about 95 per cent of the recorded storms have occurred. January has about 30 per cent of all storms, March about 25 per cent, February about 20 per cent, December about 13 per cent, April about 6 per cent, November about 2 per cent. The other six months combined make up only about 4 per cent of the storms. The monthly distribution differs, however, in several island groups. While in most January is the stormiest month and March is second,[4] in four groups March is equal to or ahead of January, and in two groups more storms have been recorded in February than in either January or March.

The number of recorded storms varies greatly. For example, in some groups and decades the information is fairly complete, for others it is fragmentary. The list for Fiji is relatively long; I spent a month there in 1921 gathering information as to storms from observers who reside in different parts of the group, and from the Government records, and newspapers. The Tonga list

[1] E. A. Beals: Barometric pressure, winds, and storms of the Pacific Ocean, *Bull. 9 of the Scripps Institution*, pp. 65-75. December, 1919.

[2] L. Froc: *L'Atmosphere en Extreme-Orient*, 2d edition, 1920, and *Atlas of the Tracks of 620 Typhoons*, 1918. J. Algué: *The Cyclones of the Far East*, 1904.

[3] Fassig, O. L.: *Weather Bureau Bulletin X*, p. 15.

[4] If the months be corrected for unequal length the differences are not so striking.—EDITOR.

comes chiefly from four sources. A short list of especially disastrous storms supplied me by the premier, a list gathered by German investigators and published in the *Segelhandbuch für den Stillen Ozean*,[5] and thirdly a list supplied me by Rev. E. E. Collocott made up from records of the Missionary College at Nukalofa. Information as to a number of additional hurricanes was gathered from sundry sources, chiefly from residents in Fiji, and from newspapers in Fiji and Australia.

The Samoan list is chiefly that compiled by the Germans and printed in the *Segelhandbuch*. The lists for New Caledonia and Norfolk Island come chiefly from information supplied by the Australian Meteorological Bureau. Barometric readings are cabled daily from these islands to Australia, and the Australian weather map extends that distance east. I studied the Australian daily weather maps for the years 1892–1921 while working in the central office of the bureau at Melbourne in 1921.

Information as to the hurricanes of other groups comes chiefly from the list in the *Segelhandbuch*, supplemented by storms mentioned in recent (1908 and 1920) editions of the Pacific Island Pilots (United States Hydrographic Office) and the Pacific Islands Sailing Directions (British). Data as to a few other storms were obtained elsewhere.

The first extensive list of hurricanes in the south Pacific is that of E. Knipping, 1893.[6] It increased Dobson's list of 24[7] to 120. In the *Segelhandbuch* (*loc. cit.*, 1897), the total was increased by 10. Schück studied the time and place distribution in his *Zur Kenntnis der Wirbelstrüme*,[8] and added 5 to the list, bringing it to 135. I have brought it to 246 in the bulletin already mentioned, where facts as to each storm are given, together with reference to the sources of information.

The final column of Table 1 consists of estimates as to the probable annual frequency of severe tropical cyclones. It is based upon the decades or series of years for which the information appears fairly complete. For example, for the New Hebrides, during the 26 years 1867–1893, 22 hurricanes are reported, but there is a gap of 8 years with no record. On this basis it appears that somewhat more than 1 hurricane is to be expected annually. But since two storms a year have been recorded in many years, and as the island groups of similar size to the east and west have averages of two or more a year, it seems reasonable to surmise that an average of nearly two storms may be expected to affect some part of the New Hebrides annually. Likewise although Table 1 mentions only 7 hurricanes from the Low Archipelago, the fact that four occurred in one 4-year period and three in another 4-year period suggests that hurricanes are not infrequent in this group. A scientist who has studied in the group and in the Marquesas reports that they occurred not rarely in both groups.[9]

The total of the several estimates of the number of hurricanes per year is 15 storms a year for island groups. However, perhaps 2 or 3 storms cross two or more groups of islands and thus appear more than once in Table 1. Thus the total number of severe tropical cyclones damaging these island groups appears to average about 12 a year. However, more than a dozen hurricanes probably occur annually in this general region, for doubtless a few unrecorded storms pass between the groups each year, especially between Fiji and the New Hebrides and between Tonga and Samoa and Cook Islands.

The occurrence of recorded hurricanes in the south Pacific by years and by months is shown in Table 2.

TABLE 2.—*Recorded hurricanes in south Pacific, by years and months, longitudes 160° E. to 140° W.*

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Month not given.	Total.
1789		1												1
1819													1	1
——					1									1
1830			1										1	2
1831												1		1
1833	1		1											2
1834													1	1
1835											1			1
1836													1	1
1837													1	1
1838													1	1
1839		1											1	2
1840		1										2	1	4
1842												1		1
1843												1		1
1845	1													1
1846			2											2
1847	1		1							1				3
1848	1	1		2								2		6
1849		1												1
1850									1					1
1851				1										1
1852		1	1											2
1854	1													1
1856	1		1											2
1859		1												1
1860	1		1											2
1861												1		1
1862	1													1
1863	1													1
1864			1											1
1865	1													1
1866			1											1
1867		1	1											2
1868	1			1	1									3
1869	3	1	3											7
1870	1													1
1871			1											1
1872		1												1
1873	1											1		2
1874		2		1							1	1		5
1875	3	1	1								1	1		7
1876	1	1	1											3
1877	2	1	2	1					1			1		8
1878	2	1												3
1879	3		2	2								1		8
1880	2	1	1											4
1881		1	1									1		3
1882	1	1	2											4
1883	2	1	2									2		7
1884	1	1												2
1885	1													1
1886	2		1											3
1887	2		1	1										4
1888		1	1										1	3
1889	1	1	3											5
1890	5	1	4								1	2		13
1891	1	4	1									1		7
1892		1										1		2
1893		1	1											2
1895	1													1
1896	1													1
1897		1												1
1898			1											1
1899												1		1
1900	1	1	1	1										4
1901	1		1	1								1		4
1902												1		1
1903	2	1	1	1										5
1904	1													1
1905	2		1											3
1906		1												1
1907				1										1
1908	1		2											3
1909				1										1
1910			1									1		2
1911	1											1		2
1912	1													1
1913		1	1	1								1		4
1914	1		2									1		4
1915	1	2	1	1										5
1916	1	1						1						3
1917			1			1						2		4
1918		1	3								1			5
1919	2	2	2	1		1	1			1		1		11
1920	2	2	2											6
1921	2	1								1	2	1		7
1922	2													2
Total	68	44	59	17	2	2	1	1	2	4	7	30	9	246

[5] *Deutsche Seewarte*, Hamburg, 1897.
[6] Knipping: Die Tropischen Orkane der Südsee, *Archiv. der Deutschen Seewarte*, 1893.
[7] Dobson: *Australian Cyclonology*, 1853.
[8] A. Schück: *Beitrage Zur Meeresjkunde, III*, Hamburg, 1906.
[9] Ralph Linton, of the Bishop Museum of Honolulu, scientific staff, oral communication.

The regions of origin of cyclones in the south Pacific according to months and location are shown in Table 3. This table is an extension of that given by Schück,[10] the approximate origin of all storms in the foregoing list not studied by him being given. As information as to exact place of origin is available for very few storms, this table gives approximate origin only.

TABLE 3.—*Region of the origin of cyclones in the south Pacific, classified according to months and locations in areas 5° square.*

[Figures following a dash (—) are of storms concerning which information is fragmentary.]

Month.	Degrees→ ↓south.	East. 160–165	165–170	170–175	175–180	West. 180–175	175–170	170–165	165–160	160–155	155–150	150–145	145–140	Total.
Jan.	5–10	—1			1		1							2—1
	10–15	1			1	2	3—7							7—7
	15–20	—1	5—2	1	14—3	—1	4—2				1—1	—2	1	26—12
	20–25	—2	3—1	—1		—1			—1					3—6
	25–30		1		—1	—1								1—2
	30–35					—1								—1
Total.		1—4	9—3	1—1	16—4	2—4	8—9		—1		1—1	—2	1	39—29
Feb.	10–15						1	1			1			3
	15–20	3—1	5	3	7—2	1	2—1				1			22—4
	20–25	1	2			—1	1—1			1				5—2
	25–30	—1	—1					—1	—1		—1			—5
	30–35				—1									—1
Total.		4—2	7—1	3	7—3	1—1	4—2	1—1	—1	1	2—1			30—12
Mar.	10–15	—1	1	—2	1	2	4—1							8—4
	15–20	—3	6		10—3	2	6—2						1—1	25—9
	20–25	5	1—1		—1	—1	—1							6—4
	25–30	—1									—1			—2
	30–35		1			—1								1—1
Total.		5—5	9—1	—2	11—4	4—2	10—4				—1		1—1	40—20
Apr.	10–15						1—1							1—1
	15–20		1	1	5		3							10
	20–25		1								—1			1—1
	25–30											—1		—1
	30–35				1	—1	2—1				—1	—1		3—4
Total.			2	1	6	—1	6—2				—2	—2		15—7
May.	15–20		1				—1							1—1
June.	25–30		2											2
July.	20–25		1											1
Aug.	25–30		1											1
Sept.	15–20		1										—1	1—1
	20–25			—1										—1
Total.			6	—1			1						—1	6—3
Oct.	15–20		1											1
	20–25		2											2
	25–30		—1											—1
Total.			3—1											3—1
Nov.	10–15							—1						—1
	15–20						2							2
	20–25			1										1
Total.				1			2	—1						3—1
Dec.	5–10													
	10–15				2	1	5		—1		1			9—1
	15–20		—1	1	6	—1	2		—1		—1			9—4
	20–25		2		—2		—1							2—3
	25–30										—1			—1
Total.			2—1	1	8—2	1—1	7—1		—2		1—2			20—9
Grand total.		10—11	38—7	7—4	48—13	8—9	37—19	1—2	—4	1	4—7	—4	2—2	156—82

[10] A. Schück, *loc. cit.*, p. 99.

Turning now to Australia and its coastal waters, longitudes 100° to 160° E., Table 4 shows the recorded tropical cyclones by years and months and Table 5 the approximate origin or place or first record, by 5°—squares by months.

TABLE 4.—*Recorded hurricanes, 100° to 160° E., Australia and adjacent waters, by years and months.*

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Month not given.	Total.
1839			1								1			2
1843		1		1										2
1850													1	1
1860		1												1
1861			1											1
1862	1		1											2
1867			2	1										3
1869			1	1										2
1870	1	3		1								1		6
1871			2		2						1			5
1872	1	2	1									1		5
1873				1										1
1874									1					1
1875			1									1		2
1876		2	1			1						1		5
1877		2												2
1878	1	1	2									2		6
1879	2					1								3
1880	2													2
1881	2		1											3
1882	1	*1	1	1										4
1883		2												2
1884	2	2	1											5
1885	1													1
1886				1										1
1887		1	2	1						1				5
1888	1	1		1								1		4
1889		1	1				1							3
1890	2		3											5
1891			1			1								2
1892	1			1							1	1		4
1893	1	3										1		5
1894	2	1	1											4
1896	1													1
1897	1											2		3
1898		2	2	1										5
1899	1	1	2	1										5
1900			1											1
1901	1	1												2
1902		1		1										2
1903	2		1											3
1904			1	1										2
1905		1												1
1906	1		1											2
1907	2		1								1			4
1908	1	1	1	2							1	1		7
1909	2	2	1	1					2					8
1910	2		1								1	1		5
1911	1	2	2								1			6
1912	2	1	3	3		1	1				1	1		13
1913	5	2		1	1							1		10
1914	2	1	1			1			1	1		1		8
1915		2	3	1								2		8
1916	2	2	2	1	2		1		1	1	1	1		14
1917	1		2	1								2		6
1918	1	2	3	1										7
1919			3	1	1		1							6
1920		3	1	2								1		7
1921	3	1	1	1	1	2	2			1	1			13
1922	2		1											3
Total.	54	49	58	29	7	7	6	0	5	4	10	22	1	252

TABLE 5.—*Approximate origin or place of first record of tropical cyclones of Australia, classified by 5°—squares and by months.*

	E.→ Lat.	100–105°	105–110°	110–115°	115–120°	120–125°	125–130°	130–135°	135–140°	140–145°	145–150°	150–155°	155–160°	E. total.
January	10–15	1	....	1	1	1	5	3	1	2	9	5	2	31
	15–20	....	....	1	8	4	1	....	....	....	2	3	1	20
	20–25	....	....	1	....	....	....	....	1	....	....	2	1	5
Total		1	0	3	9	5	6	3	2	2	11	10	4	56
February	10–15	3	....	....	1	1	1	3	2	....	3	1	8	23
	15–20	....	....	3	7	2	....	....	1	....	....	2	3	18
	20–25	....	1	3	....	....	....	....	1	1	....	....	....	6
Total		3	1	6	8	3	1	3	4	1	3	3	11	47
March	10–15	1	1	....	1	5	4	3	1	1	3	3	7	30
	15–20	1	2	....	2	4	1	....	2	....	3	1	4	20
	20–25	....	....	2	....	....	....	....	....	1	....	....	2	5
Total		2	3	2	3	9	5	3	3	2	6	4	13	55
April	5–10	....	1	....	....	1	6	....	....	....	....	....	....	8
	10–15	....	....	1	2	2	....	1	1	....	1	....	3	11
	15–20	....	....	1	2	....	....	....	....	....	....	1	1	5
	20–25	....	....	....	....	....	....	....	....	....	....	....	2	2
Total		0	1	2	4	3	6	1	1	0	1	1	6	26
May	10–15	....	....	....	1	....	....	....	....	....	....	....	....	1
	15–20	1	....	....	....	....	....	....	....	....	....	....	2	3
	20–25	....	....	....	....	....	....	....	....	....	....	....	5	5
Total		1	0	0	1	0	0	0	0	0	0	0	7	9
June	10–15	....	....	....	....	....	....	....	1	....	1	....	1	3
	15–20	....	....	....	....	....	....	....	....	....	1	....	....	1
	20–25	....	....	....	....	....	....	....	....	....	....	1	2	3
Total		0	0	0	0	0	0	0	1	0	2	1	3	7
July	10–15	....	....	....	....	1	....	....	....	....	....	....	....	1
	15–20	....	....	....	....	....	....	....	....	....	....	....	1	1
	20–25	....	....	....	....	....	....	....	....	....	1	....	3	4
Total		0	0	0	0	1	0	0	0	0	1	0	4	6
August	None.	....	....	....	....	....	....	....	....	....	....	....	....	....
September	15–20	....	....	....	1	....	....	....	....	....	....	1	1	3
	20–25	....	....	....	....	....	....	....	1	....	....	1	....	2
Total		0	0	0	1	0	0	0	1	0	0	2	1	5
October	15–20	....	....	....	....	....	....	....	1	....	....	2	1	4
November	10–15	1	....	....	....	2	2	4	....	....	....	....	....	9
	15–20	....	....	....	....	....	....	....	....	....	1	....	....	1
Total		1	0	0	0	2	2	4	0	0	1	0	0	10
December	5–10	....	1	....	....	1	....	....	....	....	2	....	....	4
	10–15	....	....	....	1	1	1	3	1	....	....	....	1	8
	15–20	....	....	1	1	....	....	....	....	1	....	2	1	6
	20–25	....	....	....	....	....	....	....	1	....	....	1	....	2
Total		0	1	1	2	2	1	3	2	1	2	3	2	20
Grand total		8	6	14	28	25	21	17	15	6	27	26	52	245

In the bulletin referred to, the storms of this region are listed under political divisions, as Queensland, Northern Territory, and Western Australia, with supplements to each list. One supplement consists of storms which recurved to the east of Queensland, not severely damaging the coastal settlements, another supplement includes the hurricanes recorded by Doctor Braak as occurring near Timor, not far from the Northern Territory of Australia. The remaining supplement includes the hurricanes recorded by A. Schück from the easternmost portion of the Indian Ocean, between the 100th meridian and the continent. Table 6 sums up the data as to the storminess of these several areas.

TABLE 6.—*Monthly distribution of cyclones, by states.*

	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Queensland:												
Hurricanes and cyclones	29	22	29	12	6	6	5	....	4	4	2	8
Lesser tropical disturbances	12	15	12	10	9	7	6	1	....	4	5	9
Northern Territory:												
On the mainland	7	4	8	2	....	....	....	....	....	....	4	7
Hurricanes near Timor	....	....	1	6	....	....	....	....	....	....	....	....
Western Australia:												
Mainland	21	17	15	7	....	1	....	....	1	1	2	8
In the East Indian Ocean	3	7	7	2	2	....	....	....	....	....	1	1

From Table 4 it will be seen that the main hurricane season extends from December to April, for during this five-month period about five-sixths of the storms occur. About three-fifths of the storms occur in January, February, and March. During the seven months May to November, inclusive, storms are rare, but rather evenly distributed, except that no severe tropical cyclone has been recorded in August.

Table 6 indicates that there is some difference in monthly distribution of storminess in the several divisions of Australia. In Queensland, the main hurricane season scarcely commences until January, while in Northern Territory nearly twice as many storms have been recorded in December as in February, and three times as many as in April. March is the stormiest month in Queensland, while in Western Australia both January and February are stormier than March. Indeed January has had nearly twice as many storms as March. In the region, Northern Territory, somewhat intermediate conditions occur, January and March being equally stormy. In the supplementary lists studied in Table 6 it is noticed that six-sevenths of the severe storms recorded near Timor occurred in April, while in the eastern portion of the Indian Ocean, February and March together have had nearly two-thirds of the total recorded storms.

Table 5 reveals a tendency for a seasonal variation in the place of origin of the storms under consideration. From November to April, inclusive, slightly over half of the storms are first noted in relatively low latitudes, 5° to 15° S., while in the other six months about five-sixths of the storms make their appearance in latitudes greater than 15°. The indications are also that a larger share originate in the interior of Australia (especially over the Gulf of Carpentaria) in the six months May to October than in the rest of the year.

The list of storms from which Tables 4 to 6 were compiled was obtained with the active assistance of officials of the Australian Meteorological Bureau, who not only facilitated my study of official records, the daily weather maps for the 20 years 1892–1921, and other information, but assisted in many ways. Indeed to Mr. David Hodge of the central office, Melbourne, is due much credit for the completeness of the Australian lists. The lists to appear in the bulletin are the first fairly complete lists for Australia. However, a list of 31 for Western Australia appeared in Hunt, Taylor, and Quayle: Climate and

weather of Australia, 1913, and a longer list of Queensland storms appeared in an official monograph on "Queensland rainfall data." However, tornadoes and thunder squalls as well as hurricanes, are listed together with no clear separation between these types.

As to the frequency of tropical cyclones in Australia: During the decade 1912–1921 there was an average of 62 storms a year, together with an average of about 8.5 storms which did not produce damaging gales in Queensland itself, although many caused gales at sea not far away. In Northern Territory and Western Australia the recent average of severe storms has been about 1.5 severe storms each. In near-by portions of the adjacent oceans there has been an average of fully two storms a year, bringing the total for this general region to well over a dozen notable tropical cyclones a year.

As to the course followed by the storms, a few quotations from the bulletin may be in order.

A study of the foregoing charts reveals certain tendencies:

(1) Although most of the storms move southward into higher latitudes they follow no prescribed paths, except perhaps across the southwestern part of the continent, from Onslow to the Bight and on toward Tasmania. Instead, some storms move southwest, others southeast, some even northward for a distance. Many change their direction of progression several times. The more tracks one traces, the more evident it is that the storms are influenced by changing atmospheric conditions, rather than by the unchanging relief features.

(2) Although all portions of Australia are occasionally crossed by tropical cyclones notable destruction upon the land has been almost lacking in the extreme southern parts of the continent. The section between Melbourne and Sydney appears to be especially fortunate in this regard, as does also the extreme southwestern corner of the continent.

(3) Roughly, a fourth of the storms recurve rather sharply, their tracks forming a parabola. Another fourth recurve less sharply, forming a hyperbola. In respect to about another fourth, the segment of the track traced might be one leg of a hyperbola. The remaining fourth of the tracks show no sign of curving on a parabolic course, being either almost straight, or curving irregularly.

(4) Where recurving is evident, on these charts, the apex of the recurve generally is in the tropical latitudes. In other words storms located poleward of the tropic nearly always are moving eastward or southeastward, while in the tropical portion of the continent many are moving westward. However, about as many are moving eastward or southward in the tropical parts of the continent as are moving westward.

(5) The storms of the main hurricane season, December to April, are much more likely to recurve on a parabolic or hyperbolic course than are the storms of the other months. Indeed, the storms of May to November have a strong tendency to follow rather straight courses.

(6) There seems to be a slight tendency for the storms which occur late in the year to be destructive farther south than those occurring in January to April. However, in April, Timor (latitude 7° to 10°) appears to be especially subject to hurricanes, and in December several severe storms have occurred in latitudes less than 20° from the Equator in Western Australia as well as beyond the tropic near 30° latitude in Queensland.

(7) Most storms gain speed as they progress, traveling about twice as rapidly in the subtropical portions of their course as in the tropical portions. In the Tropics their average speed is about 200 miles per day, while in latitudes above 30° their average is above 400 miles per day. The range in speed is high, however, some storms crossing northern Australia at the rate of 500 miles per day, while a few storms south of 30° travel 100 miles a day or less. The storms which occur out of the main hurricane season, namely those occurring from May to November, have a higher average speed than those of the main season, December to April.

(8) (*a*) A large share of the storms approach the coast of tropical Queensland from the east. (*b*) Another large share apparently originate to the north or northwest of the continent, and move southward along the coast of Western Australia, or else move inland. (*c*) Some storms appear to originate in the interior, especially near the Gulf of Carpentaria. Such storms move south, southeast, or west. (*d*) Many storms disappear in the interior of the continent. (*e*) A number of the storms have entered Queensland from the east, crossed it, and Northern Territory, passed far south along the western coast, then moved eastward, being evident on the daily weather map as far east as New Zealand, a distance of about 9,000 miles. In some cases, there is little evidence of marked decrease in intensity.

Finally, brief attention may be given to the tropical cyclones of the south Indian Ocean, longitudes 40° to 100° E. The storms occurring near Mauritius have been studied for many years by the various directors, notably Meldrum, of the Royal Alfred Observatory. Table 7 gives the storms, by years and months, from 1848 to 1919, recorded in the reports of this observatory as occurring in longitudes 50° to 70° E. Tables 8 and 9 give, respectively, the much less complete lists for the portions of the Indian Ocean to the west of 50° and to the east of 70°. These two tables are based on the lists given by Schück,[11] except that four storms described by Woods-Jones, from Cocos-Keeling Islands, are added.[12] Table 10 indicates the region of the origin of tropical cyclones in the entire south Indian Ocean. It is copied from Schück, and is based in part upon storms not included in the foregoing lists, because the list for longitudes 50° to 70° is different and fuller than the one he used. He also includes in this table storms in the easternmost part of the ocean (east of 100°), here considered with the Australian storms.

Of the storms listed in Tables 7, 8, and 9, January and February had 25 per cent each, March 20 per cent, April and December 10 per cent each, November 5 per cent, and May 4 per cent. Storms are lacking or extremely rare in the four months June to September. It appears that on the average rather more than a dozen tropical cyclones occur annually in longitudes 40° to 100° E.

[11] Schück, Wirbelstürme, *loc. cit.*, p. 58.

[12] F. Woods-Jones: Coral and atolls. The storms added are Jan. 25, 1876 (very severe), Feb. 4, 1893, Mar. 4, 1902, and Nov. 27, 1909 (very severe).

TABLE 7.—*Recorded tropical cyclones near Mauritius in south Indian Ocean, longitudes 50° to 70° E.*

[From reports of director of Royal Alfred Observatory, Mauritius. (1848-1902, in paper by Claxton; 1903-1919, from annual reports of director.)]

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
1848	2		1										3
1851			2										2
1852	2												2
1854		1	1								1		3
1855	1				1								2
1856		1	1	1							1		4
1857	1	1	1									1	4
1858	1	1	2										4
1859	2		1	1								1	5
1860	5	2	1		1								9
1861	2	2	1									1	6
1862	2		1								1		4
1863	2	2	2								1		7
1864	2	2	1										5
1865	1	2									1		4
1866	1	1		4									6
1867	1	1		1	1						1		5
1868	2	1	1	1	1					1			7
1869	1	2	1		1						1		6
1870	1	1	1	1								1	5
1871	1		1	1									3
1872	1	2	2	1	2						1		9
1873	2	2	1							1	1		7
1874	3		2										5
1875	3									1		1	5
1876	2	3										1	6
1877	2	1		1									4
1878	2	1		1								1	5
1879	1	1	1									2	5
1880	2	1										1	4
1881	2	1	1										4
1882		2	2										4
1883	1		1									1	3
1884	1	1	1									1	4
1885	2	1	1		1							2	7
1886		1		2									3
1887		1											1
1888	1	3	1									1	6
1890	1	1										1	3
1891	3	2	1								1		7
1892	1	3		1	1								6
1893	2	1	1	1							1	1	7
1894	1	2	2	1								2	8
1895	1			1									2
1896	1	1	1										3
1897		2	1									2	5
1898		2										1	3
1899	1		1									2	4
1900		1											1
1901	3											1	4
1902		4										3	7
1903	3	2	2										7
1904		2	1	1								1	5
1905	2	1	3	1								1	8
1906	1	1	1	1								1	5
1907		1	1	2	1						1	2	8
1908	1	3	2	1									7
1909	2	1	5										8
1910	1	2	1										4
1911	1	1	3								2	1	8
1912	1	4	1		1						1		8
1913	3	3	2	2								2	12
1914	4	1	2	1	1								9
1915		2	3										5
1916	2			1	1								4
1917	1	1	2										4
1918	1	2	1	1									5
1919	2	2	1		1								6
Total	94	89	70	30	14	0	0	0	0	3	15	36	351

TABLE 8.—*Recorded tropical cyclones in the south Indian Ocean between Africa and 50° E., by years and months.*

[From Schück: Zur Kenntnis der Wirbelstürme, p. 58.]

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
1851			1										1
1852	1												1
1858				1									1
1859		1										1	2
1863		1											1
1865	1												1
1869		1											1
1870	1												1
1872			1										1
1873	1												1
1874			1										1
1876		1											1
1877	1												1
1879												1	1
1885		1											1
1901	1												1
Total	6	5	3	1	0	0	0	0	0	0	0	2	17

TABLE 9.—*Recorded tropical cyclones, 70° to 100° E., in the south Indian Ocean, by years and months.*

[From Schück: Zur Kenntnis der Wirbelstürme, p. 58.]

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
1848	1		1	1									3
1851											1		1
1852	2												2
1854											1		1
1855	1				1								2
1857												1	1
1858			1									1	2
1859	1		1	1		1						1	5
1860	2	2	2	1	1							1	9
1861	2	1	1	2							1	2	9
1862	2	2	2									1	7
1863		1		1	1						1		4
1864	1		1	1									3
1865		1	1	1									3
1866		1	2	3							1		7
1867	1	2											3
1868		1									1		2
1869		2		1							1	1	5
1870				1									1
1871	2	1	1				1				1		6
1872		3	1		1								5
1873		1	2										3
1874		1	1										2
1875	1		2										3
1876	1		1									2	4
1877		1			1								2
1878				1									1
1880			1										1
1881	1	1		1	1								4
1882	1	2		1									4
1883		1	2								2		5
1884		1	2								1		4
1885	1		1	1									3
1886		1		1									2
1893		1											1
1901	1												1
1902			1										1
1909											1		1
Total	21	27	27	18	6	1	1	0	0	0	10	12	124

TABLE 10.—*Region of the origin of cyclones in south Indian Ocean, classified according to months and location in areas 5° square (1848–1905).*

[From A. Schück, Beiträge zur Meereskunde, 1906, p. 59.]

Month.	°S.	30–40	40–45	45–50	50–55	55–60	60–65	65–70	70–75	75–80	80–85	85–90	90–95	95–100	100–105	105–110	110–115	115–120	120–125	Total.
January	5–10					2	2		1		3—1	1								9—1
	10–15					6—2	2	2	1	5	1—1	2—1			1					20—4
	15–20				2—1	7—1	6	1		2	1								1	20—2
	20–25				2—2	1	1—1				—1						—1			4—5
	25–30	—1		1		—2	—1							—1						1—5
	30–35			1—1		—2														1—3
Total		—1		2—1	4—3	16—7	11—2	3	2	7	5—3	3—1		—1	1		—1		1	55—20=75
February	5–10									1		2			—1					3—1
	10–15					7	2	2	2	5	1	1	2		1	1				24
	15–20				1—1	4—1	2	3	1	2	3			1			1		1	19—2
	20–25			—1	—1				2				1			1		—1		4—3
	30–35				1—1															1—1
Total				—1	2—3	11—1	4	5	5	8	4	3	3	1	1—1	2	1	—1	1	51—7=58
March	0–5												1							1
	5–10							1			1	3	—1							5—1
	10–15			1		1	2—1		2	2	2	3	2—1		1					16—2
	15–20		—1		1—2	1—1	2—1	5—1	1	1	1				1	1—1				14—7
	20–25			—1	1—1	—1	1	—1					—1					—1		2—6
	25–30					—2		—1	—1		—1									—5
	30–35				—1												—1			—2
Total			—1	1—1	2—4	2—4	5—2	6—3	3—1	3	4—1	6	3—3		2	1—1	—1	—1		38—23=61
April	0–5											1								1
	5–10	—1					—1	1		1—1	1—1	5—3	1—2			1				10—9
	10–15			1		—1		1	3	1—1	3		1	—1						10—3
	15–20				2		2—2	1		—1		—3					—1			5—7
	20–25					1				—1										1—1
	25–30				—1															—1
	30–35	—1		—1			—1													—3
Total		—2		1—1	2—1	1—1	2—4	3	3	2—4	4—1	6—6	2—2	—1		1	—1			27—24=51
May	0–5													—1						—1
	5–10								1			2	1	1						5
	10–15							2				—1						—1		2—2
	15–20				—1	—1	—1	1			—1				—1					1—5
	25–30				—1	—1														—2
	30–25					—1	—1													—2
Total					—2	—3	—2	3	1		—1	2—1	1	1—1	—1			—1		8—12=20
June	0–5											—1	—1							—2
	5–10											1								1
Total												1—1	—1							1—2=3
July	0–5												1	1						2
August and September (no report).																				
October	0–5						1													1
	5–10												—1							—1
	15–20					—1		1												1—1
	20–25						—1													—1
	25–30	—1																		—1
Total		—1				—1	1—1	1					—1							2—4=6
November	0–5											—1	—1		1					1—2
	5–10								1	1		2—2	1—2							5—4
	10–15					—1			1		—1	2								3—2
	15–20												—1							—1
	25–30			—2	1—1															1—3
	30–35						—1													—1
Total				—2	1—1	—1	—1		2	1	—1	4—3	1—4		1					10—13=23
December	5–10											4	2			—1				6—1
	10–15		1	—1		—1	2	4	1	1			1—1							10—3
	15–20					2—1	4	1	1		—1								1	9—2
	20–25			—1	—1															—2
	30–35				—1		—2													—3
Total			1	—2	—2	2—2	6—2	5	2	1	—1	4	3—1			—1			1	25—11=36

Table 11 summarizes certain data as to the tropical cyclones in the half of the southern Tropics here under consideration.

TABLE 11.—*Summary as to tropical cyclones of half of Southern Hemisphere.*

Region.	Number of recorded cyclones.	Extremes length of record.	Number of years in which hurricanes are recorded.	Probable annual frequency.	Percentage of storms occurring in December to April.
South Pacific (160° E. to 140 W°.).	246	1784–1922	87	12	90
Australia (100° to 160° E.)	252	1837–1922	60	12	84
South Indian Ocean:					
40° to 50° E.	17	1851–1901	16		
50° to 70° E.	351	1848–1919	68		
70° to 100° E.	124	1848–1909	38		
Indian Ocean	488	1848–1919	68	12	90
Grand total (40° E. to 140° W.)	980	1789–1922	190	36	88

Representative tracks are shown on Charts I and II. The tracks of storms crossing Australia or vicinity were nearly all traced by the writer from the daily weather maps for 1892–1921. The track of the 1922 storm has been supplied by Director Hunt of the Australia Meteorological Bureau. Many of the tracks given in the author's bulletin on Australian hurricanes, already mentioned, are omitted for lack of space. About two-thirds of the tracks in the south Pacific are those given by Knipping in Bartholemew's *Atlas of Meteorology.* The other third were traced by the author from information gathered in Fiji and elsewhere, or from the records of the Australian Weather Bureau. The notable storm of March, 1910, which damaged several island groups, is charted in Hunt Taylor, and Quayles' Climate and Weather of Australia. The Knipping tracks have been dated. In Bartholemew's Atlas they are not dated. The dates were obtained from the *Segelhandbuch für den Stillen Ozean,* 1897. The south Indian Ocean tracks are mostly those given by

 Chart I.—Approximate T

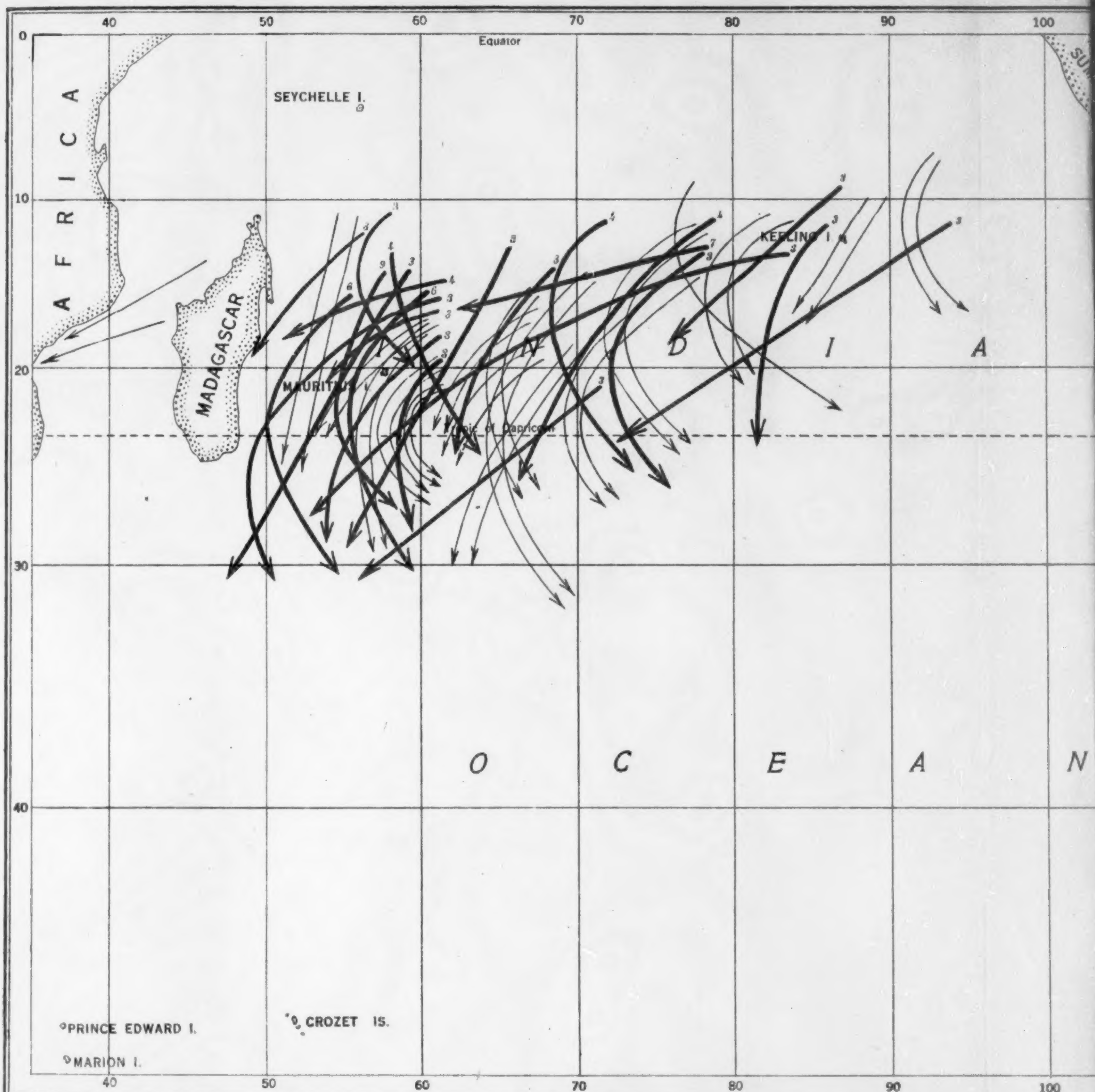
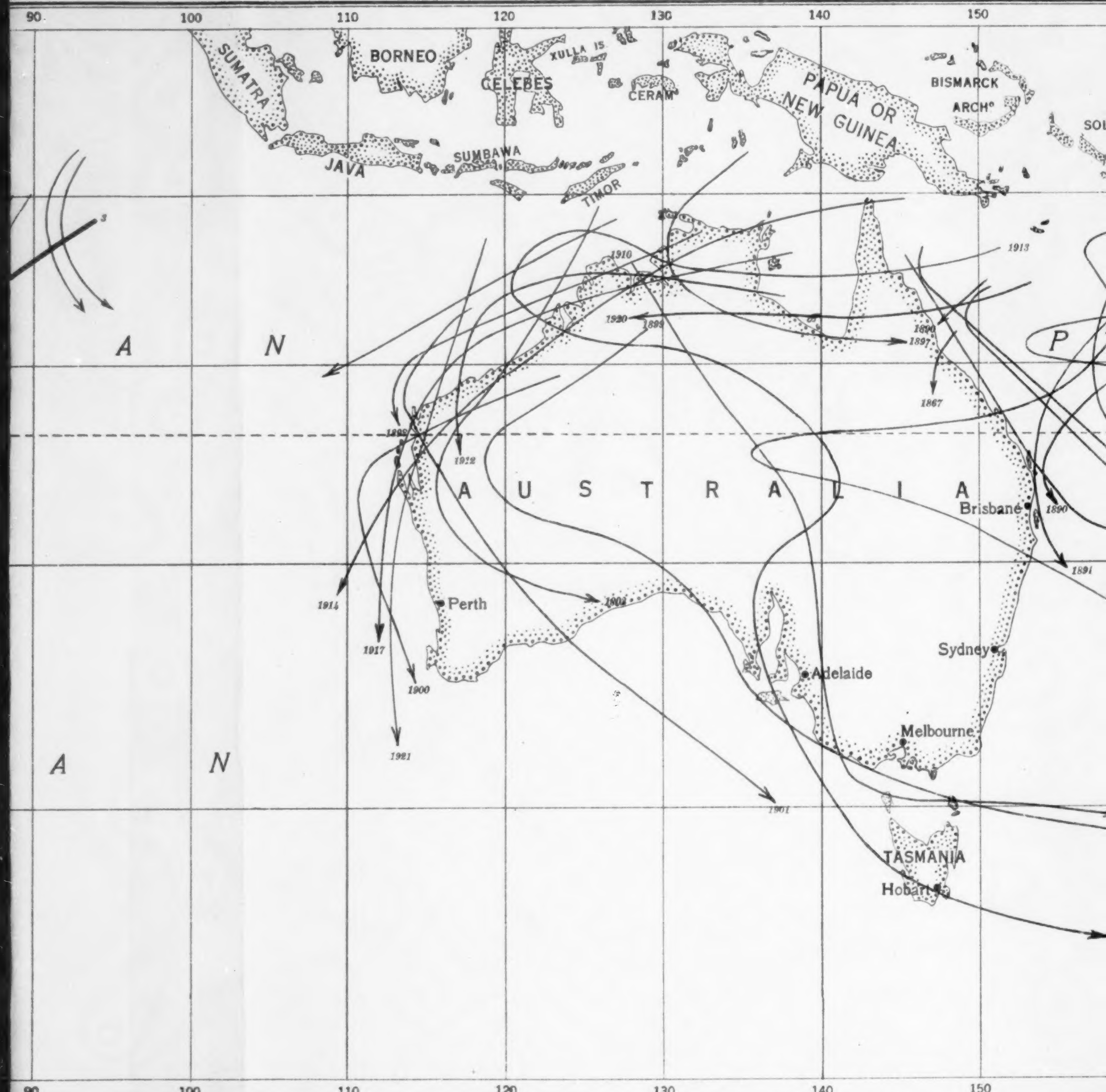
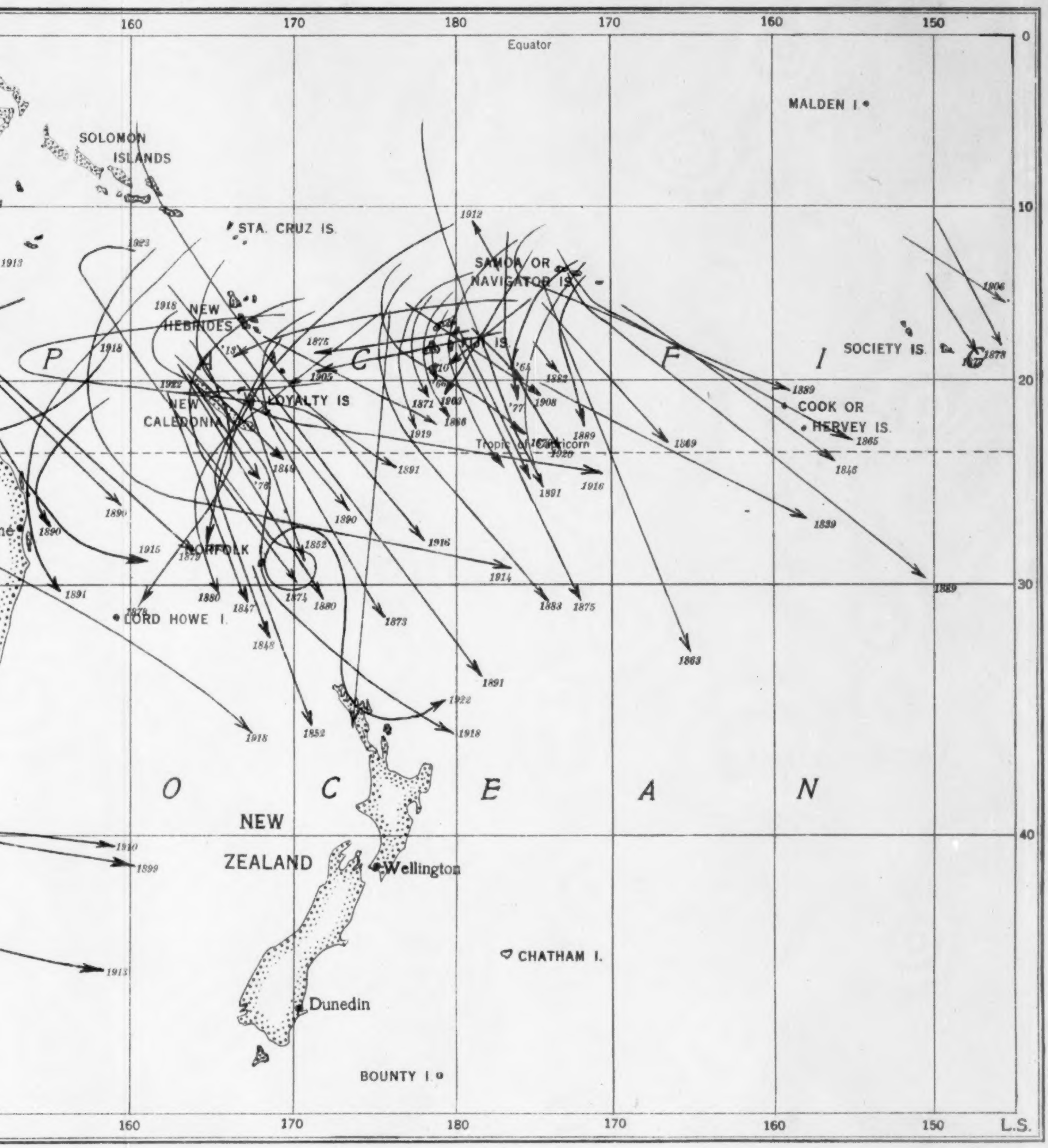
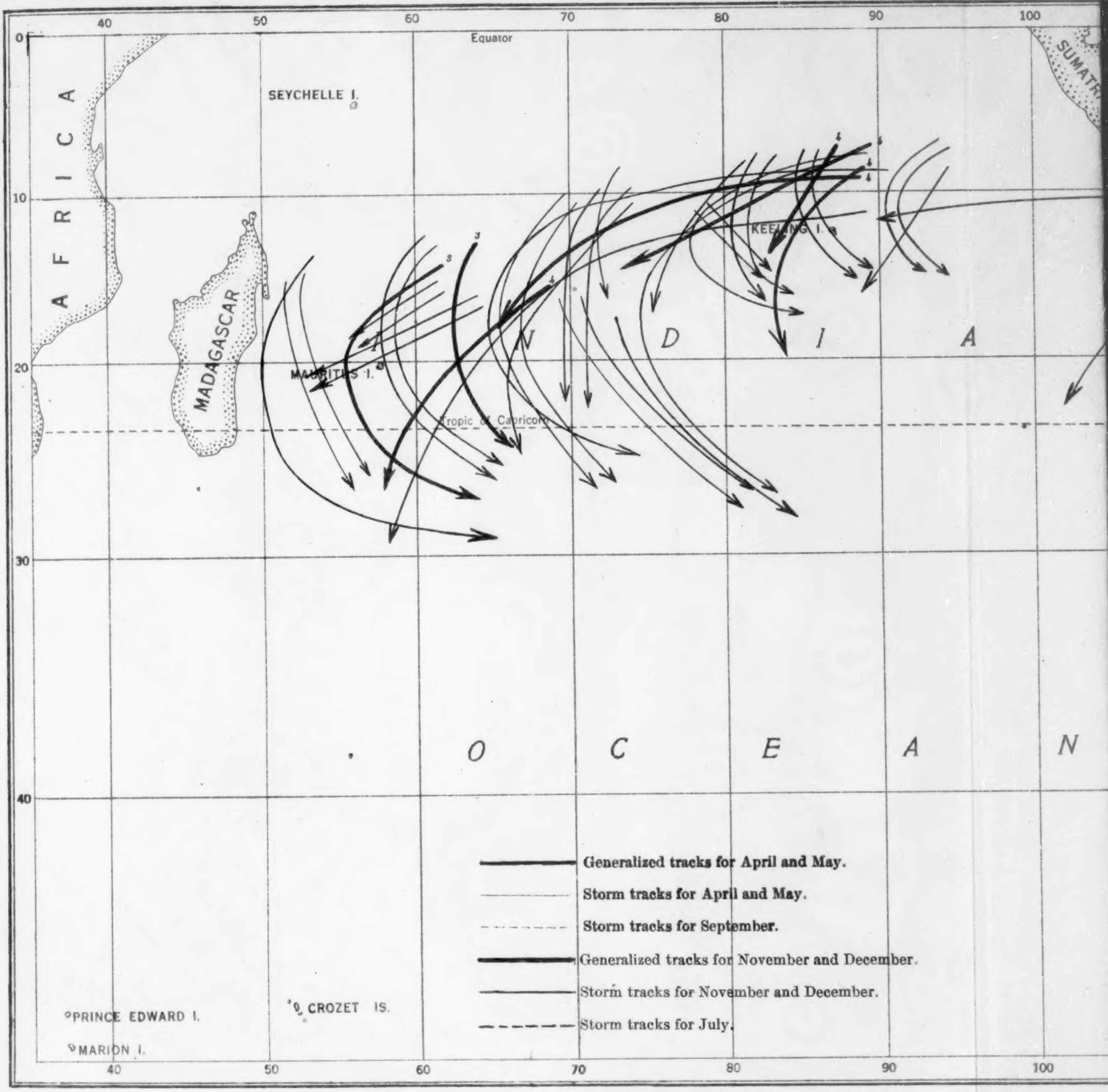


Chart I.—Approximate Tracks of Tropical Cyclones in the Indian and South Pacific Oceans for January, February

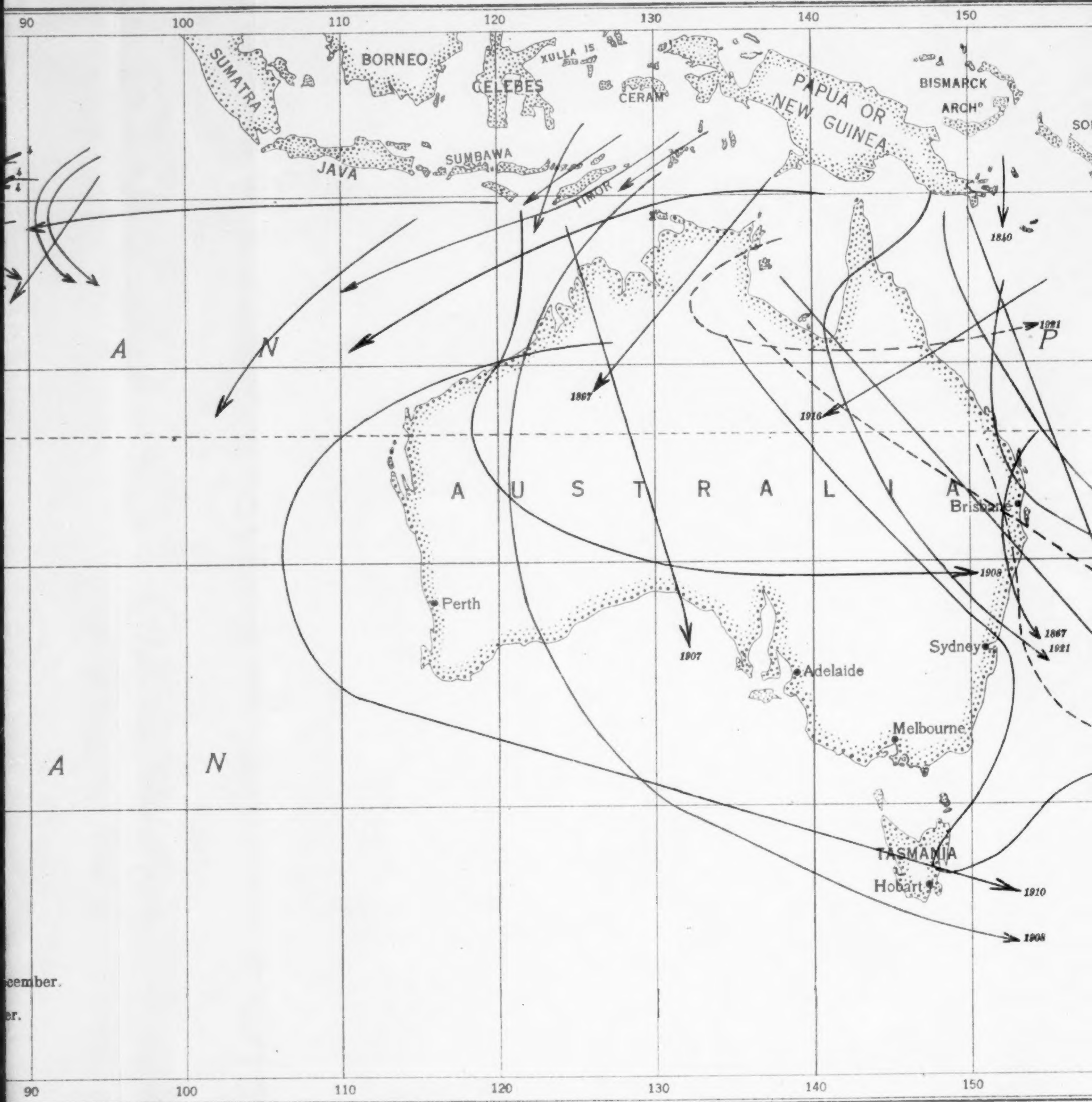


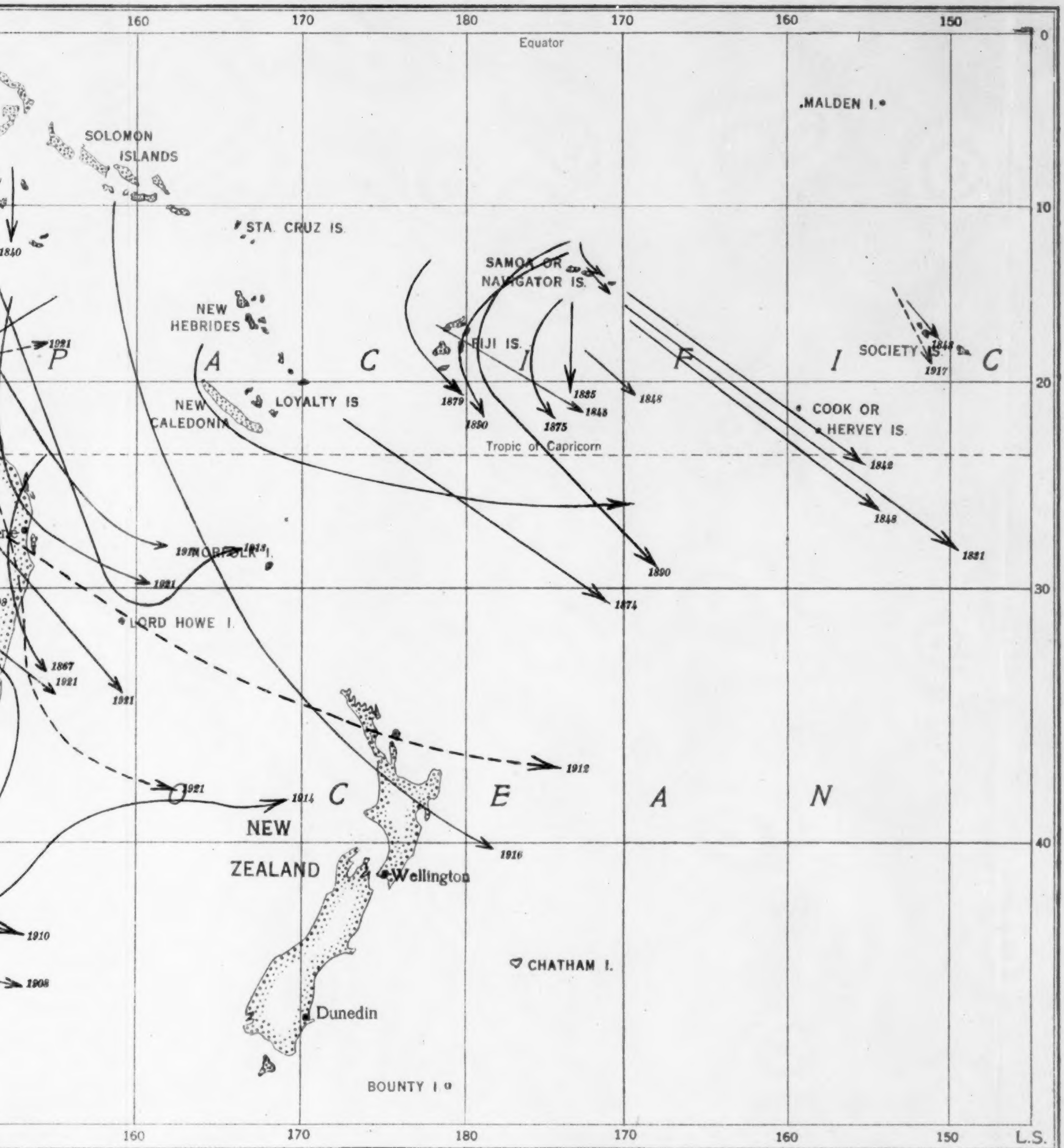

Equator
MALDEN I.
SOLOMON ISLANDS
STA. CRUZ IS.
SAMOA OR NAVIGATOR IS.
NEW HEBRIDES
FIJI IS.
SOCIETY IS.
NEW CALEDONIA
LOYALTY IS.
COOK OR HERVEY IS.
Tropic of Capricorn
NORFOLK I.
LORD HOWE I.
P A C I F I C
O C E A N
NEW ZEALAND
Wellington
CHATHAM I.
Dunedin
BOUNTY I.
L.S.

S. S. V. **Chart II.—Approximate Tracks of Tropical**



ximate Tracks of Tropical Cyclones in the Indian and South Pacific Oceans for April and May, July and Septemb




160
170
180
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Equator
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30
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MALDEN I.
SOLOMON ISLANDS
STA. CRUZ IS.
SAMOA OR NAVIGATOR IS.
NEW HEBRIDES
FIJI IS.
SOCIETY IS.
P A C I F I C
NEW CALEDONIA
LOYALTY IS
COOK OR HERVEY IS.
Tropic of Capricorn
NORFOLK I.
LORD HOWE I.
O C E A N
NEW ZEALAND
Wellington
CHATHAM I.
Dunedin
BOUNTY I.
L.S.
1840
1921
1879
1890
1875
1885
1848
1842
1881
1917
1874
1913
1867
1912
1914
1916
1910
1908

Köppen in Bartholomew's *Atlas,* which in turn were generalized from Meldrum, long director of the Mauritius Observatory. The wider lines indicate that three or more storms followed approximately that course in a 35-year period. The numeral at the end of the line indicates the number of storms along that track in that period. Koppen's charts have been combined and modified to aid in legibility and have been supplemented by several notable tracks shown in *Ein Atlas für den Indischen Ozean, Deutsche Seewarte,* 1891. The latter tracks are dated as to month, though not as to year. Köppen's tracks are dated only as to season, November and December, January to March, and April to May.

This chart and foregoing data lend little support to the oft-repeated generalization that tropical cyclones originate in a few restricted areas on the western sides of oceans at the time when the doldrums are farthest from the Equator. Many other widely accepted generalizations as to tropical cyclones appear unsafe in the light of the fuller data being gathered.

TROPICAL CYCLONES IN THE NORTHEAST PACIFIC, BETWEEN HAWAII AND MEXICO.

By STEPHEN S. VISHER.

[Indiana University, Bloomington, Ind.]

Redfield, in his paper on cyclones of the Pacific, forming a part of Commodore Perry's *Narrative of Expedition to Japan,* devotes six pages to the northeast Pacific,[1] and presents a chart showing the approximate tracks of 13 cyclones mostly in the region just west of Mexico, but partly near Hawaii. In the *Segelhandbuch für den Stillen Ozean*[2] there is a list of 45 storms occurring in that region between 1832 and 1892, no mention being made however, of those described by Redfield.

No mention of tropical cyclones occurring in this region between 1892 and 1915 has come to light except that the courses of six are traced by Hurd.[3]

Severe storms occurring in September, 1915 and September, 1918, are described in the MONTHLY WEATHER REVIEW.[4]

Since August, 1921, brief mention of four tropical cyclones has been made in the same journal.[5]

The following list includes the 70 storms mentioned in these sources of information:

List of tropical cyclonic storms in the northeast Pacific (west of Mexico and Central America and east of the longitude of the Hawaiian Islands.)

Year.	Month.	Place of origin, or first record. North latitude.	Place of origin, or first record. West longitude.	Source of information.
		°	°	
1832	December	13	148	D. S. H.
1839	Nov. 1	23	106	D. S. H.
1840	....do	22	105	D. S. H.
1842	October	15	95	D. S. H.
1843	Sept. 23	15	139	Redfield.
1847	Oct. 24	17	a 106	Redfield.
1849	June 21-22	16	116	Redfield.
1850				Redfield.
1850	June 24	16	107	Redfield.
1850	Aug. 5	14	b 117	Redfield.
1850	Sept. 9-11	15	100	Redfield.
1850	Sept. 26	26	123	Redfield.
1850	Oct. 1-6	18	104	Redfield.
1850	Oct. 3	14	c 117	Redfield.
1850	October	17	105	D. S. H.
1851	Sept. 16	15	120	D. S. H.
1851	October	21	107	D. S. H.
1851	Oct. 21	22	d 110	Redfield.
1852	July 16-19	15	e 115	D. S. H.
854	Oct. 5	28	135	D. S. H.

a NNE.
b From N.-W.-S.
c SW.-SE.-E.-N.-W.-SW.
d SE.-NE.
e From N.

List of tropical cyclonic storms in the northeast Pacific (west of Mexico aad Central America and east of the longitude of the Hawaiian Islands—Con.

Year.	Month.	Place of origin, or first record. North latitude.	Place of origin, or first record. West longitude.	Source of information.
		°	°	
1855	June	20	105	Redfield.
1855	Aug. 3-6	18	109	D. S. H.
1855	Aug. 8-9	15	f 117	Redfield.
1855	Sept. 4	20	g 122	Redfield.
1857	June 20	11	110	D. S. H.
1857	Sept. 6	19	121	D. S. H.
1858	Aug. 17	13	115	D. S. H.
1858	Nov. 21	21	174	D. S. H.
1859	Sept. 10	16	99	D. S. H.
1865	July 25	10	109	D. S. H.
1870	June 17	16	106	D. S. H.
1870	Sept. 21-24	17	141	D. S. H.
1871	July 3	16	117	D. S. H.
1874	Nov. 19	16	161	D. S. H.
1877	Nov. 5	14	123	D. S. H.
1880	July 6	20	120	D. S. H.
1880	Oct. 13	18	111	D. S. H.
1882	July 31	13	118	D. S. H.
1882	Sept. 7	14	105	D. S. H.
1883	Sept. 21-23	20	105	D. S. H.
1883	Oct. 3	23	106	D. S. H.
1884	Sept. 28-30	17	107	D. S. H.
1884	Oct. 23	24	107	D. S. H.
1885	July 31	20	130	D. S. H.
1885	Sept. 12	23	128	D. S. H.
1885	Oct. 5-6	24	108	D. S. H.
1885	Oct. 25	21	106	D. S. H.
1886	Sept. 19	16	95	D. S. H.
1887	July 6	20	114	D. S. H.
1887	Oct. 3-6	17	107	D. S. H.
1888	Aug. 9-10	15	120	D. S. H.
1888	Aug. 13-14	12	120	D. S. H.
1888	Sept. 10-11	17	106	D. S. H.
1888	Sept. 20	23	107	D. S. H.
1889	Aug. 2-3	14	122	D. S. H.
1890	Aug. 18-19	16	124	D. S. H.
1891	Aug. 2	16	118	D. S. H.
1891	Aug. 7	11	107	D. S. H.
1892	July 19	20	117	D. S. H.
1902	Dec. 23-Jan. 2	21	158	Hurd. h
1904	Nov. 26-Dec. 4	18	161	Hurd.
1904	Dec. 23-30	15	156	Hurd.
1906	May 3-10	12	152	Hurd.
1906	Oct. 2-9	18	154	Hurd.
1906	Nov. 6-13	20	157	Hurd.
1915	Sept. 4	15	110	M. W. R., 43;-486.
1918	Sept. 15-16	18	105	M. W. R., 46;-568.
1921	Sept. 24-30	20	105	M. W. R., 49;-518.
1921	Oct. 4	22	156	M. W. R., 49;-579.
1921	Oct. 9	17	102	M. W. R., 49;-581.
1922	Feb. 1			M. W. R., 50;-99.

f NE.-NNW.-WNW.-SW.
g SE.
h W. E. Hurd: Article, Cyclonic storms and typhoons of the north Pacific, U. S. Weather Bureau, January, March, and April, 1913.

The monthly distribution of these storms is shown in Table 1. All but two have occurred in the six-month period June to November, inclusive. September with 28 per cent is the stormiest month, but October with 25 per cent is only slightly behind.

[1] William C. Redfield: Vol. II, 1856, Sen. Doc. 79, pp. 354-359.
[2] *Deutsche Seewarte,* Hamburg, 1897, p. 269.
[3] Willis E. Hurd: Cyclonic storms and typhoons of the north Pacific, article on the reverse of *Meteorological Charts of the north Pacific,* U. S. Weather Bureau, January, March, and April, 1913.
[4] J. H. Kimball: A Pacific hurricane of September, 1915; MO. WEATHER REV., vol. 43, p. 486; and F. G. Tingley: Tropical cyclone of Sept. 14-17, 1918, just west of Mexico; MO. WEATHER REV., 46; 568.
[5] F. G. Tingley, MO. WEATHER REV., 49; 518, 579, 581; and 50; 99.

TABLE 1.—*Monthly distribution of the foregoing storms between Hawaii and Central America.*

	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
Number	0	1	0	0	0	5	8	10	18	16	5	1	64
Per cent of total	0	1.6	0	0	0	7.8	12.5	15.6	28.1	25.0	7.8	1.6	100

TABLE 2.—*Tropical cyclones of the northeast Pacific—Region of origin or first record of storms for 1832–1922, classified according to months and 5° squares.*

Month.	° N.	90–95.	95–100.	100–105.	105–110.	110–115.	115–120.	120–125.	125–130.	130–135.	135–140.	140–145.	145–150.	150–155.	155–160.	160–165.	170–175.	Total.
May	10–15													1				1
June	10–15					1												1
	15–20				2		1											3
Total					2	1	1											4
July	10–15				1	1	1											3
	15–20						2											2
	20–25					1	1		1									3
Total					1	2	4		1									8
Aug	10–15					1	5	1										7
	15–20				1		1	1										3
Total					1	1	6	2										10
Sept	10–15	1		2			1				1							5
	15–20		1	3	2		1	1				1						9
	20–25			1				1	2									4
Total		1	1	6	2		2	2	2		1	1						18
Oct	10–15	1					1											2
	15–20			2	3									2				7
	20–25				5	1									1			7
	25–30										1							1
Total		1		2	8	1	1				1			2	1			17
Nov	10–15							1										1
	15–20															2		2
	20–25				2										1		1	4
Total					2			1							1	2	1	7
Dec	10–15												1					1
	15–20																	0
	20–25														2			2
Total													1		2			3
Grand total		2	1	8	16	5	14	5	3	0	2	1	1	3	4	2	1	68

Table 2 indicates the approximate area of origin or of first report of these storms. This table is a revision of the one by Schück.[6] While he studies only the 45 storms listed in the *Segelhandbuch*, here 68 storms are considered, two of the 70 storms given in the foregoing list not being readily located from information at hand.

Figure 1 shows the approximate courses of about 60 tropical storms in the region under consideration. These tracks were obtained from the several sources (1), the chart by Redfield,[7] (2) a chart in the *Segelhandbuch für den Stillen Ozean.*[8] (3) A large number of the tracks were copied from the official German atlas of the Pacific.[9] (4) Several tracks are traced on Monthly Meteorological Charts [10] and Pilot Charts [11] for the North Pacific. (5) Several recent tracks are from the MONTHLY WEATHER REVIEW, especially those for 1915, 1918, and 1921.

Table 2 and especially the chart of tracks indicate that most of the recorded storms occur in longitudes 100° to 130° W. and latitudes 12° to 27° N. However it is not improbable that the entire area here shown is occasionally crossed by tropical cyclones. Certain it is that even in the midst of the large blank area between Hawaii and California gales are not lacking, although some such gales are due to steep barometric gradients on the side of the Pacific high-pressure area rather than to local storms. However, most unusually steep gradients of this sort are closely related to cyclonic storms near by.

As to the courses followed by the storms: The chart indicates that most of them travel northwest or north in this region. However, a number have recurved and progressed varying distances toward the northeast. One, at least, has crossed to the Gulf of Mexico, and over it to Florida. Others such as the storm of September, 1921, have been traced as far as Newfoundland. Still other storms move due westward and some even west-southwestward. How far such westward moving storms may

[6] A. Schück: *Zur Kenntnis der Wirbelsturme in Beitragen zur Meereskunde*, p. 81, Hamburg, 1906.
[7] Redfield: *loc. cit.*
[8] *Loc. cit.*, Tafel IV.
[9] *Atlas für den Stillen Ozean, Deutsche Seewarte*, Hamburg, 1906.
[10] U. S. Weather Bureau, 1913.
[11] U. S. Hydrographic Office, 1921.

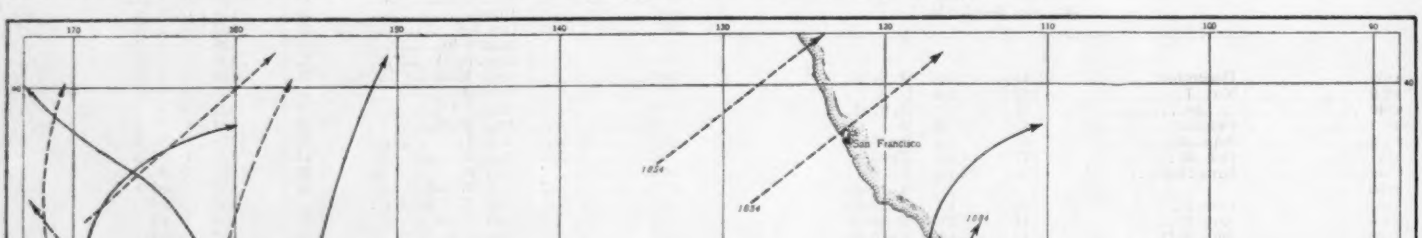


FIG. 1.—Approximate tracks of about 60 tropical storms in the Pacific Ocean between Mexico and Hawaii. Solid lines, June to October, inclusive; dashed lines, November to May, inclusive.

sometimes go before recurving is unknown, but Kimball suggests that some may cross the Pacific to Japan.[12]

As to velocity of movement, Redfield[13] reports that some move slower than any he knew of in the Atlantic, but not slower than some in the Bay of Benegal. On the other hand, some of the recent storms, for which the information is rather full, as for example the severe storm of September, 1918, moved nearly 300 miles in 24 hours.

As to severity: Tropical cyclones in this region, as in all others, vary greatly in intensity. Unusually severe storms are uncommon. The avera e storm is not so severe perhaps as the average typhoon, or West Indian hurricane, and many are not destructive to shipping, just as many typhoons and West Indian hurricanes are not destructive to shipping. But on the other hand the records indicate that scores of boats have been wrecked by storms in the northeast Pacific, and it does no good to try to ignore these storms or to say that they afford no appreciable danger.

As to frequency, the list given above suggests that two or more tropical cyclones occur on the average each year off the west coast of Mexico. Twenty-six are recorded in 11 years, 1849–1859, and 24 in 13 years, 1880–1892. In one year, 1855, seven were recorded.

[12] J. H. Kimball, *loc. cit.*

[13] Redfield, *loc. cit.*

A METHOD FOR THE CALCULATION OF NORMAL FROST DATES FROM SHORT TEMPERATURE RECORDS.

By W. B. VAN ARSDEL.

[Brown Co., Berlin, N. H., July 8, 1922.]

A few months ago the writer had occasion to examine the records of five or six cooperative Weather Bureau stations in a certain small area with a view to estimating frost risk in that area. It chanced that some of these stations had only a short record, and, accordingly, the direct averaging of frost dates, etc., was out of the question as a method of any trustworthiness, especially since some of those few years had passed without any recorded frost. Under these circumstances it was necessary to use an indirect method of computation, based on the temperature record. The occurrence of a minimum temperature of 32° or below was taken as the equivalent of a killing frost.[1] Then from the available data the smoothed curve of "normal" daily minimum temperature was drawn, and the dispersion of actual minima about the mean minimum determined. With this material it was possible to calculate the frost data usually required, namely, probable dates of first and last frost, and length of growing season in four out of five years. A search of the literature on the mathematical treatment of frost data has failed to reveal any reference to previous use of the method in question.

The fundamental idea on which the method is based is that the "average" date of, say, the first killing frost in the fall is the mean abscissa of a curve whose ordinates represent the joint probability that frost will occur and that it shall not previously have occurred (since spring); in other words, the probability that the *first* frost will occur, plotted against date, is the same curve as the frequency distribution of first frost over, say, a 100-year period, and will correspond to the same average date. It should be noted that given two stations with identical normal daily minimum temperature curves, frost will occur first at the station where actual temperatures disperse most widely about the mean; the calculation could be very greatly simplified if this dispersion could be assumed to be Gaussian, but in fact it is found to be so asymmetrical that the Gaussian formulas are useless, and graphical treatment is preferable in this case to the use of either Pearson's or Tolley's skew formulas.

. The smoothed curve of normal daily minimum temperature can not, of course, be determined very accurately from only 4 or 5 years record. A more precise method which is usually possible consists in utilizing the monthly histogram giving the normal daily minimum of a near-by station of 20 years' or longer record, averaging the differences in monthly means at the two stations during the 4 or 5 years of simultaneous record at both stations, applying the differences so found to the long record, and smoothing the corrected histogram to a continuous curve.

The dispersion of actual minima about the mean is determined directly in ogee form, recording as "probability that the temperature will be lower than n degrees above or below the mean." Table 1 summarizes the dispersion of August and September minima about the mean determined from Figure 1. The data are taken from the records of the cooperative observer at Berlin, N. H., 23 years observations being available from which to draw the mean curve.

TABLE 1.

Deviation from mean	Negative.					Positive.				
	25–20	19–15	14–10	9–5	4–0	1–5	6–10	11–15	16–20	21–25
Number of cases	0	6	20	37	49	63	50	17	2	0
Number of cases with lower temperature than given deviation.	0	6	26	63	112	174	224	241	243	243
Probability that temperature will be lower than given number of degrees from the mean	0	0.025	0.107	0.260	0.461	0.715	0.920	0.992	1.00	1.00

The ogee curve is drawn through plotted points $-15, 0.025$; $-10, 0.107$; $-5, 0.260$; $0, 0.461$; $+5, 0.715$, etc. (See fig. 2.)

The probability of frost occurrence can now be plotted against date by determining at, say, five-day intervals, the distance of the mean minimum temperature curve from the 32° line and reading from the ogee curve (fig. 2) the probability of occurrence of such a deviation from the mean. Figure 3 was drawn in that way from the given data.

It is now necessary to determine the probability that on any given date frost shall not previously have occurred; the values of Figure 3, subtracted from unity,

[1] The use of a temperature criterion of frost occurrence, while suffering from the grave drawback that damage to vegetation is not a direct function of temperature alone, still possesses several important advantages. (See, for instance, "Killing frost and length of growing season in various section of Kentucky," Ferdinand J. Walz, MO. WEATHER REV.: 45, 348, 1917, and "Weather forecasting the United States," W. B No. 583, p. 178.) Mr. William G. Reed comments in a private communication as follows: "In general, we have found that temperature methods of determining frost dates are more definite, and probably more accurate, than reports of killing frost. * * * Killing frost is really not a meteorological phenomenon at all, but it is so tied up with various questions of plant pathology that the term means different things at different times and different places."

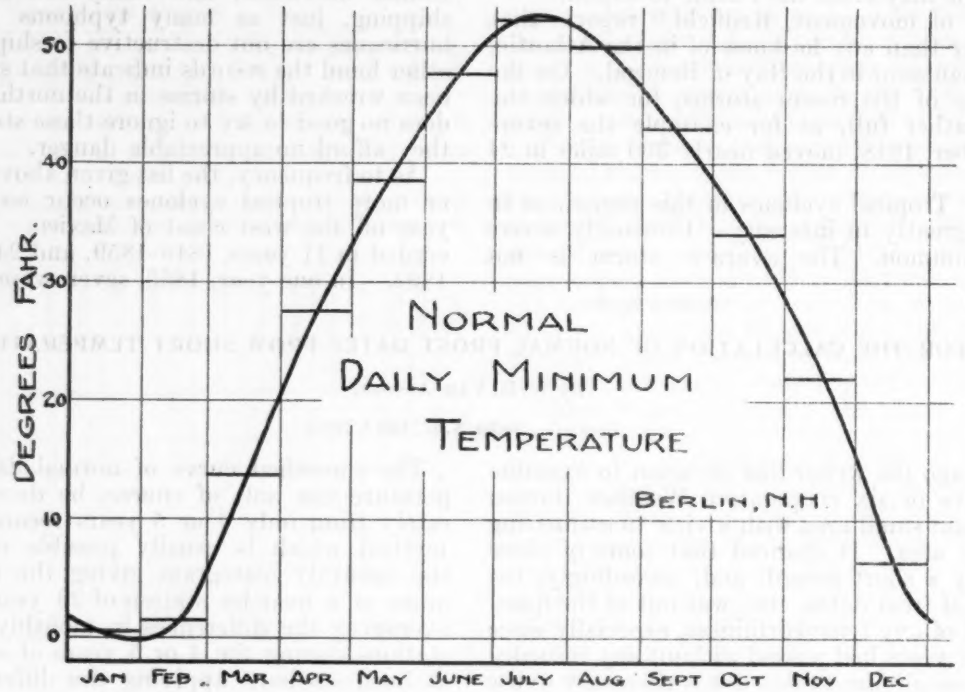

DEGREES FAHR.
50
40
30
20
10
0
NORMAL
DAILY MINIMUM
TEMPERATURE
BERLIN, N.H.
JAN FEB MAR APR MAY JUNE JULY AUG SEPT OCT NOV DEC

FIG. 1.

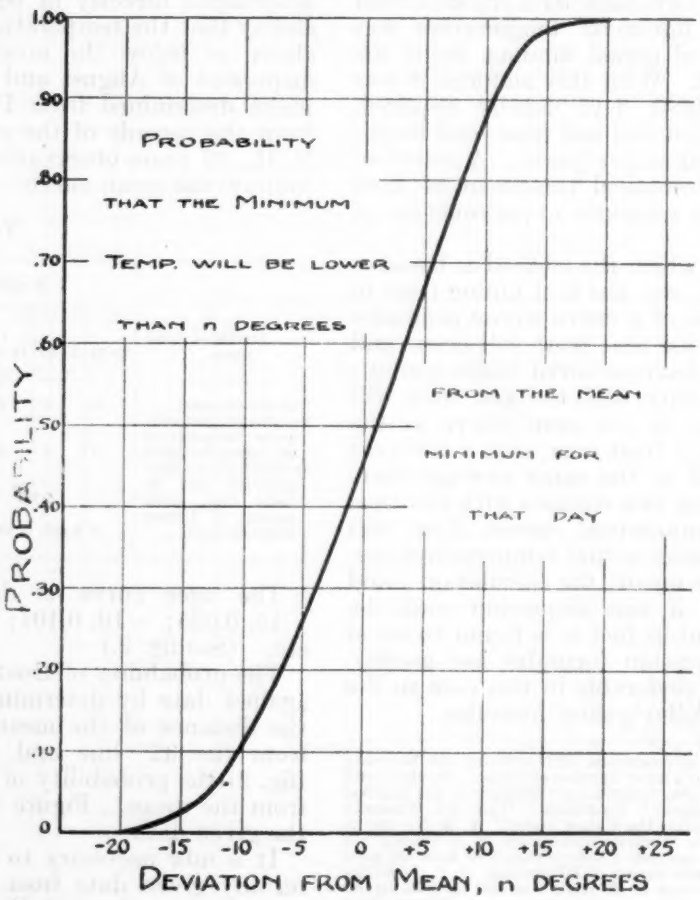

1.00
.90
.80
.70
.60
.50
.40
.30
.20
.10
0
PROBABILITY
PROBABILITY
THAT THE MINIMUM
TEMP. WILL BE LOWER
THAN n DEGREES
FROM THE MEAN
MINIMUM FOR
THAT DAY
-20 -15 -10 -5 0 +5 +10 +15 +20 +25
DEVIATION FROM MEAN, n DEGREES

FIG. 2.

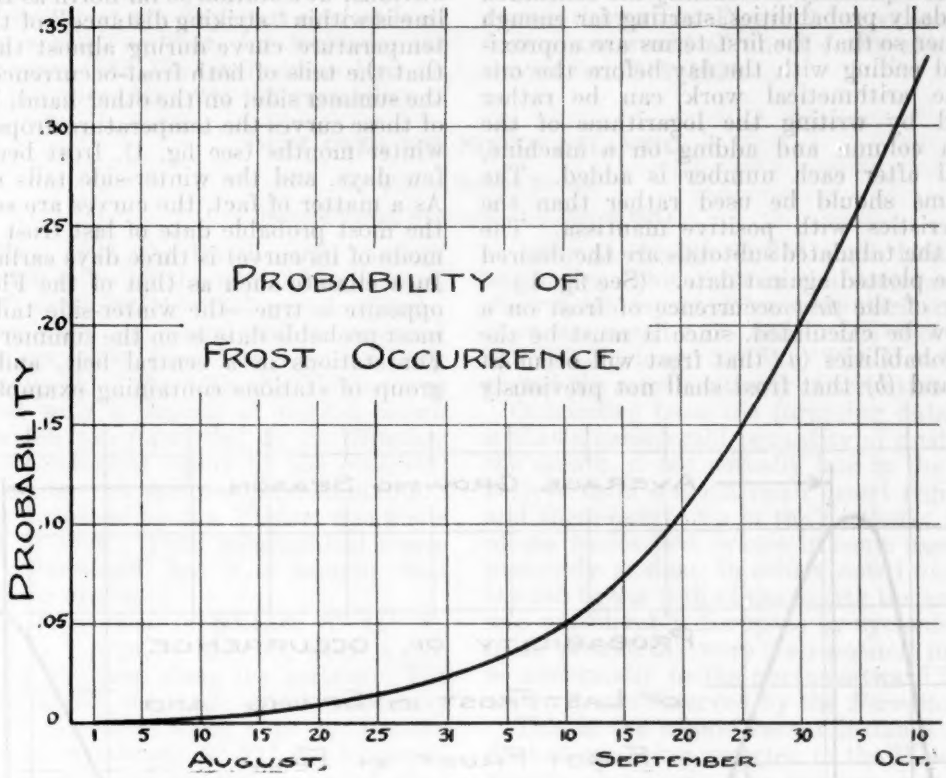

PROBABILITY OF
FROST OCCURRENCE
PROBABILITY
.35
.30
.25
.20
.15
.10
.05
0
1 5 10 15 20 25 31 5 10 15 20 25 30 5 10
AUGUST
SEPTEMBER
OCT.

FIG.

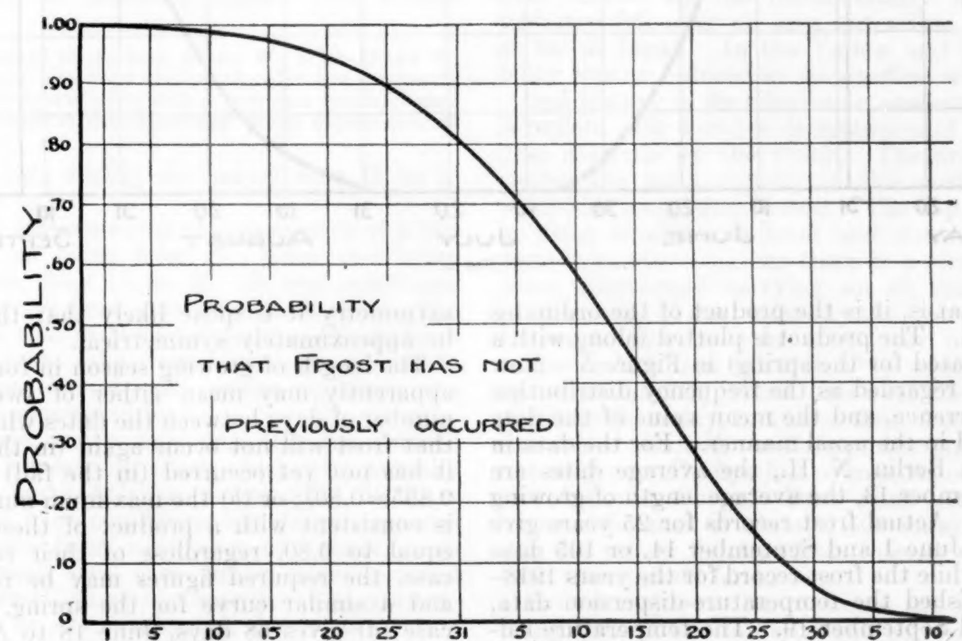

PROBABILITY
THAT FROST HAS NOT
PREVIOUSLY OCCURRED
PROBABILITY
1.00
.90
.80
.70
.60
.50
.40
.30
.20
.10
0
5 10 15 20 25 31 5 10 15 20 25 30 5 10
AUGUST
SEPTEMBER
OCT.

FIG. 4.

give the probability that frost will *not* occur on a given date, and the desired quantity is evidently the continued product of these daily probabilities, starting far enough back in the summer so that the first terms are approximately unity, and ending with the day before the one in question. The arithmetical work can be rather simply performed by writing the logarithms of the probabilities in a column and adding on a machine, taking a subtotal after each number is added. The negative logarithms should be used rather than the negative characteristics with positive mantissa. The antilogarithms of the tabulated subtotals are the desired probabilities, to be plotted against date. (See fig. 4.)

The probability of the *first* occurrence of frost on a given day can now be calculated, since it must be the product of the probabilities (*a*) that frost will occur at all on that day, and (*b*) that frost shall not previously have occurred; that is, it is the product of the ordinates of Figures 3 and 4. The product is plotted (along with a similar one calculated for the spring) in Figure 5. Now this curve can be regarded as the frequency distribution of first-frost occurrence, and the mean value of the date can be determined in the usual manner. For the data in question, i. e., at Berlin, N. H., the average dates are May 30 and September 13, the average length of growing season 106 days. Actual frost records for 25 years give as average dates June 1 and September 14, or 105 days growing season, while the frost record for the years 1918–1921, which furnished the temperature-dispersion data, gives May 28 and September 19. The temperature calculation results in average dates which are not only much nearer to the long-period average, but especially with regard to the spring date are also inherently more precise.

Previous writers on the occurrence of frost have usually regarded its occurrences as being distributed normally about the average date.[2] The curves of Figure 5 are, however, markedly asymmetrical, and the reason is quite obvious; at a station so far north as Berlin, N. H., the 32° line is within "striking distance" of the normal minimum temperature curve during almost the entire summer, so that the tails of both frost-occurrence curves are long on the summer side; on the other hand, beyond the maxima of these curves the temperature drops rapidly toward the winter months (see fig. 1), frost becomes certain every few days, and the winter-side tails are relatively short. As a matter of fact, the curves are so asymmetrical that the most probable date of last frost in spring (i. e., the mode of its curve) is three days earlier than the average. In a climate such as that of the Florida Peninsula the opposite is true—the winter-side tails are long, and the most probable date is on the summer side of the average. For stations in a central belt, and particularly for a group of stations containing examples of both kinds of asymmetry it is quite likely that the distribution will be approximately symmetrical.

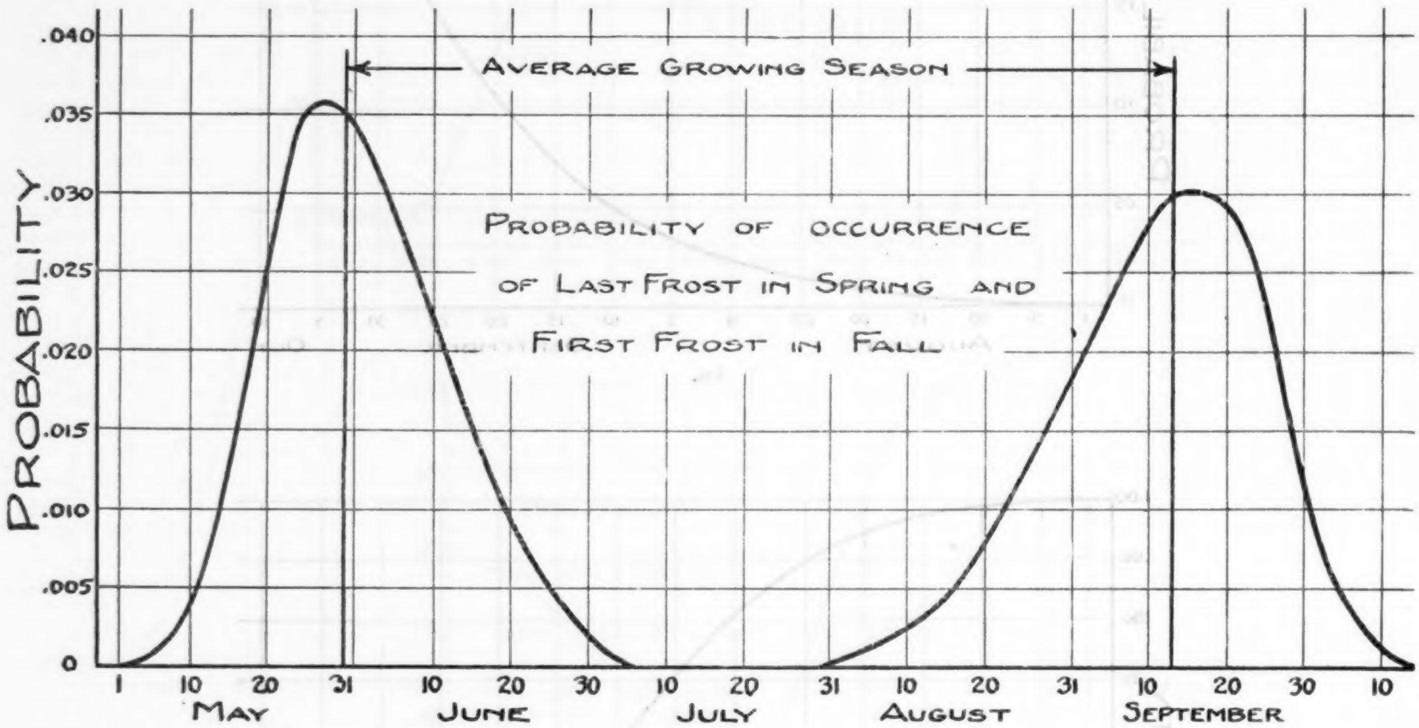


FIG. 5.

The length of growing season in four out of five years apparently may mean either of two things: (*a*) The number of days between the dates when the probabilities that frost will not occur again (in the spring) and that it has not yet occurred (in the fall) are both $0.895 \times 0.895 = 0.80$); or (*b*) the maximum number of days which is consistent with a product of these two probabilities equal to 0.80, regardless of their equality. In either case, the required figures may be read from Figure 4 and a similar curve for the spring. For this station, case (*a*) gives 68 days, June 18 to August 25, case (*b*) gives 69 days, June 19 to August 27. It is, of course, true that this calculation is only approximate, since the dates of spring and fall frost are undoubtedly correlated, and the joint probability of the two events is not simply equal to the product of their probabilities; such correlations as have been observed, however, would not change the result markedly.

A final word as to why any more accuracy can be claimed for the temperature method than for the simple

[2] See, for instance, "Probable growing season," by W. G. Reed, Mo. WEATHER REV. 44, 509 (1916). The deviations from the normal date are tabulated for a large number of stations and a single frequency curve drawn for the entire group. This curve is shown to be approximately Gaussian.

averaging of frost dates for the same number of years. The actual dates of last frost are dispersed over at least two months in the spring, so that, for instance, the average for the four years 1888–1891 inclusive is June 17, and for 1897–1900 inclusive, May 21; the variability of minimum temperature is much less erratic, so that ogee curves drawn like Figure 2 for various other periods of four years would all check fairly closely with that one, drawn for 1918–1921.

DUST OVER THE NORTH ATLANTIC.

By WILLIS EDWIN HURD.

[Weather Bureau, Washington, D. C., July 18, 1922.]

On the 12th of May, 1922, the Dutch cargo steamer *Yildum* was about 250 miles off the west African coast, in approximately 14° north latitude, 21° west longitude, For more than three days the vessel had experienced winds from north to northeast, force 1 to 5, with a hazy atmosphere. At daybreak of the 12th the *Yildum* was found to be covered with a deposit of reddish-brown dust, a sample of which was forwarded to the Weather Bureau with his meteorological report by the observer, Second Officer W. Mulder. A microscopic examination of the dust particles furnished by the *Yildum* was made by the U. S. Bureau of Soils. Their geographical source was not definitely determined, but it is assured that they are not of volcanic origin.

The Dutch S. S. *Hagno* was in latitude 8° 11′ N., longitude 50° 5′ W., at 8 p. m. of May 13, when a reddish mist or haze was observed along the horizon. The haze continued throughout the 14th, wind constantly from a northeasterly direction, force 4 to 5. On the afternoon of the 15th, in latitude 5° 21′ N., longitude 45° 2′ W., a heavy shower and sudden change of wind cleared the air, the rain bringing down a "kind of red sand or dust."

Mr. G. MacGregor, second officer of the British S. S. *Dundrennan*, made the following report in a similar connection:

> 11th to 15th May: Lat. 7° 47′ N., long. 44° 26′ W., to lat. 18° 44′ N., 53° 22′ W. (L. M. noon). The hazy weather recorded was apparently due to the fact that the air was laden with a very fine reddish-brown sand similar to that found in the Harmattan winds experienced off the west coast of Africa.

The observed winds during the period were E. by S. to E. by N. force 4 to 7.

The British S. S. *Parima* noted the prevalence of a fine white haze while en route from St. Kitts and other islands to Barbados, May 13 to 18. It was sometimes so dense as to obscure land 1 to 2 miles distant. The observer concluded that as Mount Pelee was said to have been in slight eruption (the writer has been unable to obtain any confirmation of such recent activity), the haze might thus be accounted for.[1]

The citations given are the only ones thus far received by the Weather Bureau in which dust was actually reported over the north Atlantic during May, 1922, or in which abnormal haze conditions were given especial notice. Observations from a number of vessels, however, indicate a vast area over which haze occurred between the 9th and 23d of the month. The easternmost known limit of observation of the haze or dust was about the 21st meridian, in 14° or 15° north latitude; the westernmost, in the Caribbean Sea and the Gulf of Mexico.

The latitudinal width of the haze area seems to have been greatest about mid-ocean, between the 5th and 35th parallels. The American S. S. *Harvester* observed haze as early as the 9th in 35° north latitude, 41° 17′ west longitude. This date is the same as that of the first observation reported from the African coast area. The *Harvester* noted haze daily until the 13th, when in lat. 33° 40′ N., long. 53° W. The Dutch S. S. *Hagno* reported the most southerly observation.

Concluding from the foregoing data, the assured fact is that a considerable quantity of dust was very early in the month, if not actually late in the preceding month, derived from some African desert region, carried to sea, and there caught up in the northerly and easterly winds of the trades belt, where in some cases it was observed positively as dust; in others noted only as haze. From the 6th to the 10th of the month the area of high pressure was considerably disrupted by cyclonic conditions, which in all probability were instrumental in carrying the dust so abnormally to the northwestward beyond the trades, where it was observed by the *Harvester*.

This is the second recent instance of observations of dust at sea being reported to the Weather Bureau by its marine observers. The previous instance is that given by the American S. S. *Santa Rosalia*, April 15, 1921, in the Yellow Sea, coincident with the passage of a severe extratropical cyclone over the Mongolian Desert. The dust carried by the northwesterly winds of this disturbance fell over an area extending eastward at least as far as Japan. In the Yellow and Eastern Seas visibility was so reduced as to interfere with navigation.

Soil history in its relation to erosion and stratification is replete with world-wide instances of the movements of dust material by the winds. The drier the locality of course the more rapidly is this surface accumulation wind-blown and distributed. The deposition of soil dust in some localities is local and considerable in a brief period; in other regions there is a slower, steadier, and more widespread carrying on of this condition. The total amount of dust swept by the sirocco from the Sahara Desert to Europe year after year during the last 30 centuries has been calculated[2] as equivalent to an average of at least 5½ inches, less over the British Isles and northern Germany, but more than that over the southern countries. Indeed, the Sahara dust has been distributed not only over Europe but over parts of Africa, Asia, and the Atlantic Ocean. Dust from Australia has been borne a distance of about 1,500 miles to New Zealand, and the yellow detritus from interior China has likewise been transported far to sea.

Severe major cyclonic storms are likely to catch up many tons of fine material and carry much of it as they progress. In cases of violent local storms like desert whirlwinds a quantity of dust may be taken far aloft, where it passes from the brief control of the ascensional currents and spreads out into the great horizontal wind systems.

It is a dispersion of the former type that is instanced in the dust observations of April, 1921, in the western Pacific, and quite possibly a dispersion of the second type which has been herein especially discussed as affecting so great an area of the north Atlantic.

[1] Since writing the foregoing, the writer has seen a copy of *The Meteorological Magazine* of London for July which contains an extract from the *Barbados Advocate*, May 23, 1922. Attention is there called to the extraordinary "prevalence of a low hanging mist which has shut off the horizon" over the Carribean Sea from Barbados to St. Kitts and almost to Demarara. The idea that the phenomenon was due to volcanic dust, at first prevailing, was later discarded. But "no scientific explanation of the phenomenon has yet been offered."—*W. E. H.*

[2] Free, E. A.: Movement of soil material by the wind. *Bulletin No. 68*, Bureau of Soils, 1911, p. 99.

RELATIONS BETWEEN THE WEATHER AND THE YIELD OF WHEAT IN THE ARGENTINE REPUBLIC.

By N. A. HESSLING, in charge of Rainfall Section, Argentine Meteorological Office.

[Translated from *Boletin Mensual*, Oficina Meteorologica Argentina, April, 1919.]

Wheat is the most important crop in the Argentine Republic. During the last 10 years the area seeded to this cereal has varied between 6,000,000 and 7,000,000 hectares (1 hectare = 2.47 acres); that is about twice the area covered with corn. As the yield of corn is more or less double that of wheat, the production in tons is about the same for the two cereals, although when we count the value of the respective crops, wheat again becomes the more important.

The average yield of wheat in the last 30 years, according to data published in the *Agricultural Statistics*, has been 720 kilograms per hectare, taking the country as a whole. Table 1 gives the yield for each year from 1890 to 1919. The maximum yield was 1,216 kilograms per hectare, obtained in 1893, and the minimum 333 kilograms in 1916. The variations in the yield from year to year, therefore, have been considerable, although not as large as in the case of corn.

TABLE 1.—*Yield of wheat in kilograms per hectare in the Argentine Republic.*

[By sown area.]

Year.	Yield.	Year.	Yield.	Year.	Yield.
1890	703	1900	602	1910	635
1891	742	1901	466	1911	656
1892	996	1902	764	1912	737
1893	1,216	1903	817	1913	434
1894	835	1904	837	1914	735
1895	559	1905	647	1915	692
1896	344	1906	746	1916	333
1897	559	1907	909	1917	883
1898	893	1908	701	1918	714
1899	851	1909	611	1919	991
Means	770	Means	710	Means	681

Mean yield for 30 years (1890-1919), 720 kilograms per hectare.

TABLE 2.—*Mean rainfall (millimeters) in the wheat zone of the Argentine Republic.*

Year.	May.	June.	July.	August.	September.	October.	November.	December.
1890	26	2	35	25	4	31	83	88
1891	51	43	53	64	21	85	67	88
1892	11	2	26	56	5	87	87	50
1893	45	8	37	16	9	25	87	27
1894	46	7	36	20	23	103	95	91
1895	35	86	13	39	95	91	96	182
1896	51	5	47	16	77	87	128	114
1897	50	28	16	23	27	61	75	127
1898	27	53	8	19	18	74	80	135
1899	45	19	35	49	42	58	70	79
1900	79	55	39	72	84	98	83	89
1901	40	26	10	22	43	82	87	52
1902	82	14	24	2	31	69	86	110
1903	31	52	29	38	43	47	94	102
1904	7	27	44	33	53	101	132	64
1905	50	17	30	19	43	151	64	115
1906	26	35	55	47	32	71	64	69
1907	17	12	12	35	60	72	76	99
1908	68	47	53	11	57	70	109	63
1909	12	16	33	27	113	72	101	75
1910	29	8	11	13	48	63	54	34
1911	84	89	53	38	34	124	109	187
1912	62	47	25	55	34	104	122	127
1913	70	17	13	92	55	68	113	81
1914	103	35	69	55	40	103	134	159
1915	29	4	7	15	43	80	73	108
1916	28	6	4	22	12	17	37	90
1917	6	37	60	7	55	36	31	52
1918	36	46	5	10	84	92	148	91
1919	100	63	79	10	90	93	109	150
Averages	45	30	32	32	46	77	90	97

In the yield of corn, it has been shown that the principal factor is the rainfall, and the next the temperature. The present study is an attempt to determine the effect of these factors on the yield of wheat.

Effect of the rainfall variations on the yield of wheat.—The rains that might be expected to affect the yield of wheat in this country, seeing that it is sown in the months of May to August, the harvest beginning in November or December, would be those that fall from June to November. In Table 2 are given the average amounts of rainfall over the wheat zone of the Republic, that is, over the Provinces of Buenos Aires, Entre Rios, Santa Fé, Cordoba, and Pampa Central Territory. Although the yield data of Table 1 really refer to the whole country, what is produced outside of this zone forms only a small portion of the whole.

A comparison of these data with those of the yield in Table 1 shows that between the two there is very little relation. The six years of largest yield were 1893, 1892, 1919, 1907, 1898, and 1917. In five of these the total rainfall of June to November was below the normal, and in the other, 1919, it was excessive. The yields were lowest in 1916, 1896, 1913, 1901, 1895, and 1897. Of these, 1916 was the driest of all, in 1897 and 1901 the rain was below normal, while in the remaining three it was above normal.

TABLE 3.—*Yield of wheat (kilograms per hectare) in the Argentine Republic.*

[Averages according to rainfall in the months June to November.]

	Millimeters of rain.							
	Less than 100	100-150	150-200	200-250	250-300	300-350	350-400	400-450
Number of cases	1	0	3	4	6	6	5	5
Average yield	333	....	851	724	819	728	593	729
Maximum yield	....	....	1,216	883	996	817	837	991
Minimum yield	....	....	635	559	466	647	344	559

Grouping the yield data according to the rainfall from June to November, and taking averages of the yield for every 50 millimeters of rainfall, as shown in Table 3, it will be seen that the maximum yield corresponds to rains of 150 to 200 mm. In the first group, corresponding to rains of less than 100 mm., there occurs only one case, that of the year 1916. There are no cases of rainfall between 100 and 150 mm., which shows the exceptional character of the year 1916, and the average of the next group is the maximum, from which it seemingly might be inferred that the only year in which the wheat suffered from want of rain was 1916. But perhaps it is not correct to consider the yield in relation to the total rainfall of the six months. The rain in certain months is no doubt more effective than in others, and besides, in six months there may occur periods of drought that might affect the wheat, although the total rainfall of the six months be sufficient. For this reason the yield data have also been analyzed with respect to the rainfall of the four months July to October and the three-month periods June–August and September–November.

TABLE 4.—*Yield of wheat (kilograms per hectare) in the Argentine Republic.*

[Averages according to rainfall in the months July-October, June-August, and September-November.]

Periods.	Millimeters of rain. Less than 50.	50-75	75-100	100-150	150-200	200-250	More than 250.
July-October:							
Number of cases	0	1	2	6	8	10	3
Average yield	......	333	*960*	738	786	631	776
Maximum yield	......	......	1,216	893	996	837	991
Minimum yield	......	......	703	559	466	344	602
June-August:							
Number of cases	4	9	4	8	5	......	......
Average yield	606	710	*846*	750	745	......	......
Maximum yield	764	1,216	996	851	991	......	......
Minimum yield	333	344	611	434	602	......	......
September-November:							
Number of cases	0	1	0	3	10	5	11
Average yield	......	333	......	*934*	770	669	676
Maximum yield	......	......	......	1,216	996	909	676
Minimum yield	......	......	......	703	559	434	602

These means show a similar distribution to those of June to November; that is, the maximum yield is obtained on the average with rains, that differ little from the minimum observed. But in whichever way the averages are formed it must be admitted that they do not show any marked correlation between rainfall and yield. If this correlation existed there would be some symmetry in the averages; that is to say, after rising to a maximum they would gradually diminish, forming when expressed graphically a curve more or less pronounced, but without the waves or irregularities shown by these. Both by this lack of symmetry, as well as by the large differences between maxima and minima in each group, it may be inferred that the rainfall is not the principal factor in the yield of wheat, at least when considering the yield of the country as a whole, with the mean rainfall in the corresponding zone.

But perhaps this lack of correlation is due to the fact that the area considered is too large. The area where wheat is cultivated is very extensive, and in some years the rainfall may be insufficient in some parts of this area and excessive in others. The best would no doubt be the data for departments (counties), because even the provinces, especially Buenos Aires, still comprise areas too large to refer their rainfall to an average quantity. But it seems there are no data available by departments, and the only more detailed data I have been able to obtain are those of the Provinces of Buenos Aires, Entre Rios, Santa Fé, Córdoba, and the Territory of Pampa Central during the years 1908–1918, which are given in Table 5.

TABLE 5.—*Yield of wheat (kilograms per hectare), by Provinces, 1908-1918.*

[By harvested area.]

Year.	Buenos Aires.	Entre Rios.	Santa Fé.	Córdoba.	Pampa Central.
1908	792	739	714	678	350
1909	723	680	501	650	821
1910	758	632	556	634	756
1911	822	744	672	610	662
1912	836	597	687	750	731
1913	536	422	440	441	554
1914	844	544	671	806	810
1915	852	909	799	605	595
1916	551	460	467	353	216
1917	804	1,224	1,068	1,070	745
1918	989	572	860	642	643
Averages	773	684	749	658	626

These data differ from those of Table 1 in having been taken from the area harvested instead of the sown area; that is, in this case the total failures have been eliminated. The true yield should of course be computed from the sown area. There might, for instance, be cases of total loss through drought, in which case the yield computed from the harvested area would be too large. On the other hand, in some cases this method might be more advantageous, as when the failure is due to other causes than those the subject of investigation, for instance in this case, if they were due to frost, hailstorms, or causes not meteorological.

The data for 11 years are, of course, insufficient to determine the correlation between rainfall and yield for each Province. The effect of the rainfall is not necessarily the same in different regions. It no doubt varies with the temperature, the character of the soil, the topography, and other factors. But to determine these differences by statistical methods would require much more data than we possess. However, utilizing the existing data as far as possible, and disregarding, for the present, the differences of correlation that may exist in different regions, we will see, if with these data it is possible to determine the effect of the rainfall with more precision than with those from the country as a whole.

With this object in view, the averages of Table 6 have been computed, which have been formed, grouping the data from any Province according to the mean rainfall in the respective Province.

TABLE 6.—*Yield of wheat (kilograms per hectare) in the Provinces Buenos Aires, Entre Rios, Santa Fé, Cōrdoba, and Territory of Pampa Central.*

[Averages according to rainfall, June-November, June-August, and September-November.]

June-November.	Millimeters of rain. 25-50	50-100	100-150	150-200	200-250	250-300	300-350	350-400	400-450	450-500	Over 500
Number of cases	1	2	4	7	8	7	7	6	4	7	2
Average yield	353	612	530	680	*846*	796	620	658	749	701	558
Maximum yield	.....	756	595	1,068	1,224	852	836	806	989	866	572
Minimum yield	.....	467	216	551	605	678	440	536	597	422	544

June-August.	Millimeters of rain. Less than 10	10-25	25-50	50-100	100-150	150-200	200-250	250-300
Number of cases	5	6	9	16	12	3	3	1
Average yield	585	588	671	*751*	704	708	631	544
Maximum yield	662	821	822	1,070	1,224	844	687	......
Minimum yield	467	350	460	216	422	536	507	......

September-November.	Millimeters of rain. 25-50	50-100	100-150	150-200	200-250	250-300	300-350	350-400	400-450
Number of cases	1	5	11	6	11	13	5	2	1
Average yield	353	450	*797*	687	674	720	650	751	572
Maximum yield	......	756	1,224	909	852	989	844	860	......
Minimum yield	......	216	561	556	440	501	422	642	......

On the whole, these averages are similar to the first ones, and they show, that the most favorable condition for the wheat is, when it rains in the three winter months 50 to 100 mm., and in September to November 100 to 150 mm. If it rains less than these quantities, it is insufficient, and if it rains more, the yield in general decreases. This decrease, however, is not at all propor-

tional to the increased rainfall, there being cases of high yield with abundant rains, and it does not seem that the decrease of the yield after the maximum can be attributed directly to the excess of rain. It seems rather that the rainfall, as long as it is sufficient, or say about 100 to 150 mm. in three months, does not affect the yield greatly, and that the decrease of the yield with larger rainfalls is caused by other factors.

So far we have considered the yield with respect to the winter and spring rains independently from each other. But it seems probable, that the effect of the spring rains will vary according to the rains fallen before in the winter, and this is really what is shown by Table 7.

TABLE 7.—*Yield of wheat analyzed according to the combined rainfall of winter and spring.*

[Rainfall in millimeters.]

	Rainfall of September to November.						
	Less than 50.	50-100	100-150	150-200	150-250	250-300	300-350
Rainfall, June-August, less than 25:							
Number of cases	1	3	2	2	1	2	0
Average yield (kilograms per hectare)	353	524	628	598	605	*736*	......
Rainfall, June-August, 25-50:							
Number of cases	0	1	1	1	4	0	2
Average yield (kilograms per hectare)	......	460	554	632	777	......	642
Rainfall, June-August, 50-75:							
Number of cases	0	0	3	1	1	2	0
Average yield (kilograms per hectare)	......	......	676	*909*	852	612	......
Rainfall, June-August, 75-100:							
Number of cases	0	1	3	1	1	2	1
Average yield (kilograms per hectare)	......	216	*981*	792	750	723	860
Rainfall, June-August, over 100:							
Number of cases	0	0	2	1	4	7	5
Average yield (kilograms per hectare)	......	......	*991*	507	524	746	652

The averages of this table have been computed, first grouping all the cases according to the rainfall of June to August. Then in each of these groups the yield has been analyzed with regard to the rainfall of September to November. Although the data are certainly very scanty to be treated in this way, still the position of the maximum in each primary group clearly shows, that the need of rain in the spring decreases in proportion as the winter rains have been larger. The table also shows, how important are the winter rains for the wheat yield, the maximum yields with winter rains of less than 50 mm. being much smaller than maxima and even than the yield in general, when the winter rainfall has been greater than 50 mm.

When the rainfall of the three winter months has been less than 25 mm., the maximum yield is obtained with the highest amount of rain observed in spring. That is, if there has been drought in winter, in the spring the rainfall will never be excessive, or at least it has not been so in the 11 years covered by this study. As the winter rains increase, the quantity of rain necessary in spring to obtain the maximum yield decreases until with winter rains of more than 100 mm., the maximum yield corresponds to the lowest amounts of rain in the spring. Of course it can not be inferred, that if in this case the spring rains had been still less, the yields would be larger, because however abundant the winter rains may be, they can not altogether replace the spring rains. It is though, fairly certain, that if it has rained enough in the winter, the spring rains will also be sufficient, because the severe droughts in spring are always preceded by dry winters.

TABLE 8.—*Yield of wheat (kilograms per hectare) in the Provinces Buenos Aires, Entre Rios, Córdoba, Santa Fé, and Territory of Pampa Central.*

[Averages according to bimonthly rainfall.]

Periods.	Millimeters of rainfall.									
	Less than 10	10-25	25-50	50-75	75-100	100-125	125-150	150-175	175-200	Over 200
May-June:										
Number of cases	3	13	12	7	5	5	6	1	1	2
Average yield	593	642	661	728	*766*	746	749	671	572	570
June-July:										
Number of cases	15	7	10	5	10	4	3	0	1	0
Average yield	538	607	712	736	824	*866*	674	......	544	......
July-August:										
Number of cases	9	8	13	8	6	4	3	3	1	0
Average yield	649	577	*766*	757	673	660	562	653	544	......
August-September:										
Number of cases	0	4	5	15	16	6	4	2	1	2
Average yield	......	512	686	*747*	724	664	648	540	680	497
September-October:										
Number of cases	0	2	3	3	11	8	9	11	7	1
Average yield	......	410	477	499	*806*	641	631	738	729	572
October-November:										
Number of cases	0	0	3	9	5	3	1	9	10	15
Average yield	......	......	598	641	*828*	504	536	693	702	673

Table 8 has been made with the object of showing more exactly at what time the rains are most necessary for the wheat. For this table the yield data have been arranged according to the bimonthly rainfall, beginning with May to June. Approximately the effect of the rains may be judged by the difference between the groups of maximum and minimum yield. The difference is largest for the months of September to October, in which it amounts to 396 kilograms per hectare. June, July come next with 328 kilograms, which confirms what has been noticed before about the importance of the winter rains.

Apparently in August the rains are less necessary, possibly because at this time the plant may require more sunshine, and the amount of sunshine will naturally, in general, vary inversely to the rainfall.

Summing up the results, it may be said, that the rainfall in the Republic, excepting very rarely, is sufficient to obtain a good yield of wheat. Taking the country as a whole, the only case of real drought in the last 30 years was the year 1916. Considering the data by Provinces, there are more cases of diminished yield by that cause, that is by partial droughts, felt in one or in some of the Provinces. Specially in the winter and in the interior of the country, as in Córdoba and the Pampa, where the winter rainfall is normally very scarce, the want of rain is felt more frequently.

The most favorable quantity, that is with which the highest yields have been obtained, is about 100 mm. in June and July and another 100 mm. in September to October. The normal rainfall in the winter is less than this in Córdoba, the Pampa, and western Buenos Aires, while in spring it is more throughout the wheat region.

These results, however, correspond only to averages, but the correlation between rainfall and yield of wheat is very vague, and in individual cases the variations of the yield with similar rainfall are so large that it would be quite useless to attempt forecasting the yield by the rainfall alone.

Possibly the results would have been more definite if more detailed data had been available as by departments or smaller regions. Besides to determine with more exactness the real effect of the rain, it would be necessary to have data respecting the time of sowing, which varies

somewhat in different Provinces and from year to year, because naturally the critical time of growth will differ according to the time of sowing.

EFFECT OF THE TEMPERATURE VARIATIONS ON THE YIELD OF WHEAT.

Data covering the period since 1890 are not available from a large enough number of stations to compute the real average temperature over the wheat zone. But the variations from the normal can be computed by a much smaller number of stations, because the temperature variations are nearly the same over this entire region. For Table 9 only the data from three stations have been used, Buenos Aires, Córdoba, and Bahia Blanca; the first two are the only ones that cover the entire period, and the observations at Bahia Blanca begin in 1896. First the differences from the normal have been computed for each station, and then the average taken of these differences.

The mean of these three stations could not be considered as representing the temperature in the wheat region, and besides the inclusion of Bahia Blanca in 1896 would introduce a change in the normal. However, the variations are nearly always in the same sense at the three stations, and when they are large at one, they are also large at the other two, so that the mean of the three can quite well represent the variations of the temperature over all this region.

TABLE 9.—*Deviations from normal temperature in the wheat zone of the Argentine Republic.*

Years.	June.	July.	August.	September.	October.	November.
	°C.	°C.	°C.	°C.	°C.	°C.
1890	−1.2	0.2	−1.1	−1.4	0.7	1.8
1891	.6	−.9	.8	.2	0	.2
1892	−2.0	.5	−1.1	−.7	.3	−.6
1893	−1.9	.8	−1.2	−2.0	−2.5	−.4
1894	−1.4	−.8	−.4	−.8	−1.3	0
1895	2.8	1.2	1.4	.6	−.7	−.3
1896	−1.2	2.7	3.8	2.1	1.2	1.0
1897	.3	−2.1	−.8	−.4	1.6	.7
1898	.6	−1.9	−2.0	−.9	−1.8	−1.7
1899	−2.1	3.0	.8	−.7	−.7	−.9
1900	.6	1.6	0	.7	−.1	.9
1901	3.0	−.4	.2	2.0	2.1	.7
1902	1.3	−.9	−2.0	−.3	.5	.1
1903	.1	0	0	2.0	−.6	−.3
1904	.2	1.3	−.5	.8	−.2	−1.2
1905	.2	−1.8	.5	.4	−.3	−.1
1906	2.2	−.1	.7	−.5	1.2	.1
1907	−.9	−.3	−1.2	−1.4	−.9	−.1
1908	1.3	.2	−1.1	.1	.3	0
1909	−1.1	−.3	2.2	.8	−.5	−1.8
1910	1.0	−1.1	.9	.2	1.2	.9
1911	−1.1	0	−1.3	−2.3	−1.0	−.2
1912	.4	−1.3	−1.2	.6	.8	−.3
1913	1.2	3.1	1.0	1.0	.7	1.6
1914	2.3	1.8	.1	−.6	−.2	−2.1
1915	−2.7	.6	1.6	−.3	.6	1.3
1916	−3.8	−2.4	.3	1.5	2.0	1.1
1917	.9	−.9	−.7	.4	0	.8
1918	−.7	−.1	.5	−1.3	−.3	.1
1919	−.1	−.2	−.7	−1.3	−.7	−.9

If these data are compared with the yield figures, at once a much closer correlation is brought into evidence than in the case of the rainfall. In nearly all the years with large yield the deviations in the spring months are negative, that is the temperature has been below normal, and in those with small yield they are positive or above normal. Of course there are some exceptions, but the only really notable exception is 1911, when the spring was cold, and notwithstanding this, the yield was below the average. It is known though, that in this year the harvest, which at first was very promising, was spoilt by the heavy rains, that fell in December. In a large part of the zone over 300 mm. fell in that month, the wheat fields in many places being flooded at harvest time.

In general the yield seems to be more or less inversely proportional to the temperature, which fact allows the relation between temperature and yield to be expressed by the correlation coefficient, a simple and practical method, but which could not be employed in the case of the rainfall, because between the rainfall and the yield there is no linear correlation.

Computing the correlation coefficient, the yield and bimonthly temperatures, beginning with June-July, we get:

June-July	−0.10
July-August	−.32
August-September	−.69
September-October	−.75
October-November	−.67

The temperatures of June and July apparently have no influence but in August their effect is already well apparent, coming to their maximum in September and October. Combining several months, the maximum correlation is −0.81, for the four months August to November and taking out the year 1911, in which the low yield was due to the heavy rains at harvest time, the coefficient becomes −0.86.

According to W. H. Dines (*Meteorological Magazine*, London, February, 1921) the effect of one variable over another is to be measured by the square of the correlation coefficient. The square of 0.86 is 0.74, so therefore 74 per cent of the variations in the wheat yield are due to variations in the temperature in the months of August to November.

There have been cold and dry springs, like 1893 and 1898, cold and wet like 1919, and in nearly every case, when the temperature has been markedly below the normal, the yield of wheat has been high. Likewise there are cases of a warm and dry spring, like 1910 and 1916, and warm and wet, like 1896 and 1913, and in all of these cases the yield of wheat has been low. Consequently there is no doubt that the temperature is a much more important factor that the rainfall in determining the yield of wheat.

It is of interest in this connection to consider the relation between the temperature and rainfall. When studying the effect of these elements on the yield of corn, it was found that in summer the droughts are generally accompanied by high temperatures, the explanation evidently being that when the air is dry, the solar rays pass more easily through to the earth's surface, while when the air contains more moisture, a greater proportion of heat is absorbed by the upper layers of the atmosphere. In winter the opposite is the case, the dry winters being usually cold, and the wet ones warm, because the terrestrial radiation at this season being greater than the solar, the drier the air, the greater will be the loss of heat. In the intermediate season of spring, the incoming and the outgoing radiation being balanced, the variation of each element is less dependent on the other.

The variations of temperature, contrary to what is the case with the rainfall, being nearly always general in character, their effects on the wheat will be better studied on a large zone, because in that way the local variations are in a great part eliminated. In Table 5 it can be seen, that in some years the yield varies considerably from one Province to another. As the variations of temperature are nearly alike in all the provinces, these differences of yield must be ascribed to more local factors, among which may be included the rainfall. It

is to be expected, therefore, that the correlation coefficient between the provincial yields and the corresponding temperatures will be smaller than when the yield in the whole country is considered. However, it will be of interest to see the variation of the correlation, month by month, in each Province, although the period of 11 years is too short to attach much value to the correlation coefficients. These are given in Table 10.

TABLE 10.—*Correlation coefficients between the monthly temperatures of each Province and the corresponding wheat yield.*

	June.	July.	August.	September.	October.	November.
Buenos Aires	0.19	−0.02	−0.27	−0.72	−0.43	−0.12
Entre Rios	.02	−.29	−.39	−.26	−.21	.10
Santa Fé	.14	−.21	−.42	−.33	−.23	.18
Córdoba	.49	−.27	−.45	−.15	−.42	−.23
Pampa Central	.50	.04	.18	−.36	−.58	−.48

In the more northern Provinces of Entre Rios, Santa Fé, and Córdoba, where the wheat is generally sown and harvested earlier, the temperatures of August have the greatest effect; in Buenos Aires it is those of September, and in the Pampa those of October.

In June, the coefficients are positive, but only in Córdoba and the Pampa are they large enough to be significant, showing that in the interior of the country an increase of temperature in June is beneficial. The reason probably is that the temperature is higher in the wet winters, and the winter rain in these regions, where it generally is insufficient, is a factor of some importance for the wheat yield.

POSSIBILITY OF COMPUTING THE YIELD BY MEANS OF THE METEOROLOGICAL ELEMENTS.

The principal practical application of these relations is of course, their utilization as an aid in forecasting the crop. The correlation between the temperature and the yield of wheat is so close that with this element alone it is possible to forecast with a fair approximation the resulting crop. As the yield is more or less inversely proportional to the mean temperature of the months August to November, a constant would have to be found, that, multiplied by the temperature or by the departures from the normal, would give the yield. This constant, called generally "regression factor," can be computed by the formula $b=\frac{\Sigma xy}{\Sigma x^2}$, in which b is the regression factor, x the causative variable, in this case the temperature, and y the resulting variable, in this case the yield.

For the whole country b results $= -208$ for the months of August to November, that is, for each degree, that the mean temperature of those months is higher or lower than the normal, the yield of wheat will diminish or increase respectively 208 kilograms per hectare.

In Table 11 are given the yields for each year from 1890 to 1919, computed by means of this coefficient and the deviations of the temperature from the normal, the differences between these computed yields and the actual ones being also given.

TABLE 11.—*Yield of wheat (kilograms per hectare) computed by means of the temperature of August to November and difference between this and the actual yield.*

Year.	Computed yield.	Difference with obtained yield.	Year.	Computed yield.	Difference with obtained yield.
1890	720	−17	1905	699	−52
1891	658	+84	1906	637	+109
1892	824	+172	1907	907	+2
1893	1,032	+184	1908	762	−61
1894	845	−10	1909	678	−67
1895	678	−119	1910	554	+81
1896	304	+40	1911	970	−314
1897	658	−99	1912	720	+17
1898	1,053	−160	1913	491	−57
1899	803	+48	1914	866	−131
1900	637	−35	1915	554	+138
1901	470	−4	1916	470	−137
1902	803	−39	1917	699	−184
1903	658	+159	1918	762	−48
1904	782	+55	1919	907	+84

In Figure 1 the computed yields are compared graphically with the yields obtained. The resemblance of the two curves is remarkable, considering that only one element has been used in the computations, while the yield naturally results from various factors.

The differences between the computed and the actual yields can be considered as what is left of the variations of the yield, when the temperature effect has been deducted, and consequently it might be expected that these residuals would show better than the total variations, the effect of less active factors, like the rainfall.

Analyzing these differences according to the rainfall, it is seen that in 1916 the difference is negative, which is doubtless due to the drought of that year. On the average, the differences are also negative, when the rain has been excessive, but the year 1919 is an exception. With rainfall nearly normal, the differences on the average are positive, but in this case the extreme values vary so much, that in general it does not seem that the results would gain much in accuracy by including the rainfall as a factor in the computations.

The appraisal of this factor is, as has been seen, rather difficult. A relatively small quantity may be sufficient, if it is well distributed over the growing period, while a larger quantity may be insufficient, if badly distributed. For instance, what saved the crop in 1893, was undoubtedly the fair amount of rain that fell in July of that year, which allowed the wheat to withstand the relative drought of the next three months (see Table 2); without that rain, or if it had fallen later, say in September, it is very probable that the crop of that year, instead of being the best of these 30 years, would have been much below the normal, notwithstanding the favorable temperature. In 1898 the temperature was also favorable, but the yield, although above normal, does not come up to the value computed by the temperature. In this year there was also a drought of three months, but in this case it started in July, that is a month earlier than in 1893, which seems to be the principal difference between the two years.

Some of the negative differences, besides 1911, already mentioned, may be due to excessive rains during the harvest season, a factor that is of course actually impossible to foretell. This seems notably to be the case in

1895 and 1914. Another cause of diminished yield might be the late frosts. The most notable year in this respect was 1908, in which occurred a sharp frost in the middle of October; however, in this year the difference, although negative, is not one of the largest.

As the rainfall might possibly have an indirect effect, modifying that of the temperature, and to try if, taking into account this modification, it would be possible to make the computations more accurate, the data have been divided into three groups according to the rainfall. For this purpose the rainfall from July to October was used, although the result would obviously have been about the same if some other period, like June to November had been used. The first group comprises those cases, in which the rainfall of these four months was less than 150 millimeters, the second, the rainfall of 150 to 200 mm. and the third, when it was above 200 mm. Then the correlation between the yield and the temperature of August to November has been computed for each group. The coefficients are respectively −0.83, −0.85 and −0.89, and the regression coefficients −204, −205 and −206 (excluding the year 1911).

The differences of the regression coefficients are obviously too small to modify appreciably the computations, but the correlation coefficient increases somewhat with the rainfall, that is, when the rain has been abundant, the yield computed by the temperature will be more nearly accurate, while with smaller rainfall, the yield is more likely to be affected by other factors not related to the temperature.

The temperature, as has been seen, although it does not permit us to compute the yield with exactness, can serve as a very useful auxiliary factor to forecast the crops. The computations here given have been made with the temperatures of August to November, that is, they can be made at the beginning of December. However, they could be made with almost the same accuracy with the temperatures of August to October, when they could be made at the beginning of November. The correlation coefficient in this case is −0.85 and the regression factor −186. Computing the yield with this latter coefficient and the temperature deviations of August to October, the mean of the differences between computed and obtained yield, without distinction of sign, is 91, while in the first case it is 83, excluding in both cases the year 1911.

THE SPECIFIC WEIGHT OF THE WHEAT.

Besides the yield, the specific weight of the wheat is also of interest. Like the first, it varies from year to year, and in different localities, variations that no doubt also are related to meteorological phenomena. For the specific weight of the wheat there are data published in the *Agricultural Statistics* since 1908 from each department.

Analyzing these data with respect to the rain and temperature does not reveal any relation with these elements, excepting that the greater specific weight corresponds in general to the scantiest rainfall. It does not seem likely, that the rainfall has in reality the effect of diminishing the specific weight, but this is more probably an indirect effect, and related really to the sunshine, which in general varies more or less inversely with the rainfall.

There are no sunshine data, except from very few stations, but instead the data of cloudiness can be used, which is more or less inversely proportional to the sunshine. Grouping the data of specific weight from those departments, where a meteorological station exists, according to the cloudiness observed, we get the averages given in Table 12.

TABLE 12.—*Specific weight of wheat (kilograms per hectoliter).*

[Averages according to grades of cloudiness.]

PROVINCE OF BUENOS AIRES.

	Grades of cloudiness.						
	1	2	3	4	5	6	7
June	64.0	71.6	75.4	77.6	76.5	74.3	....
July	78.0	77.2	77.3	76.2	75.9	72.8	....
August	77.1	76.1	76.1	76.7	75.5	74.8	....
September	77.6	77.5	76.6	76.0	75.2	74.5	....
October	....	78.8	76.3	76.5	74.2	78.6	77.3
November	....	76.3	76.8	75.3	75.1	75.5	....
December	77.0	76.5	76.6	77.0	70.4	74.9	....

SANTA FÉ AND CÓRDOBA.

	Grades of cloudiness.						
	1	2	3	4	5	6	7
June	77.9	77.3	76.5	76.3	77.2	76.3	....
July	79.6	75.9	77.1	76.9	76.5	77.0	74.8
August	....	78.1	76.3	75.8	77.5	76.3	....
September	81.5	77.6	77.1	76.1	76.7	75.6	....
October	81.5	79.0	77.2	76.9	75.3	74.1	....
November	79.7	78.5	77.8	76.6	75.2	76.5	....
December	78.1	79.6	77.3	75.9	75.6	71.9	....

As can be seen the maximum specific weights correspond to the minimum of cloudiness and in general also the minimum weights to the maximum of cloudiness. The diminution is in general progressive as cloudiness increases, so it may be concluded that the specific weight varies inversely with the cloudiness or in direct ratio to the sunshine.

The individual data certainly do not always show such a close relation as these averages, but these show

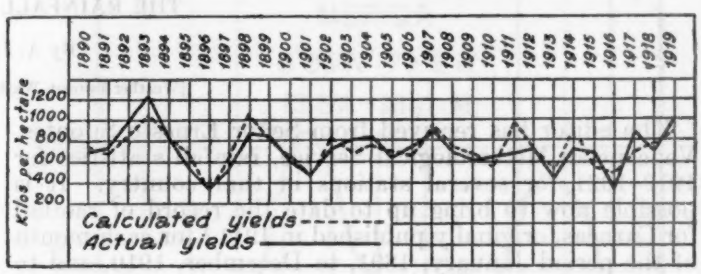


FIG. 1.—Graphical comparison between yields calculated by the temperature of August-November and actual yields. (Dotted line=calculated yields; solid line=actual yields.)

that the sunshine is the principal factor in determining the specific weight.

The averages have been computed separately for the Province of Buenos Aires and for Córdoba and Santa Fé, the data from Entre Rios and the Pampa being too scanty to use. The two series generally agree, but the differences between maximum and minimum are larger in Córdoba and Santa Fé.

If we measure the relative effect of the sunshine by the difference between maximum and minimum weight, the month in which this element is most important seems to be December, that is when the grain is ripening. It also seems to be important in July and in October.

The result would probably have been better with the sunshine data, because the cloudiness only approximately

represents the former. Besides the data of cloudiness on account of the manner in which this element is observed is subject to variations due to the personal criterion of the observers, and even the international conventions are not yet agreed on some points in this respect. For instance, when the sky is covered with cirro-stratus it is a doubtful point whether the observer should put 10 (overcast), seeing that these clouds let through the greater part of the sunshine.

As the sunshine has this effect on the specific weight, it might be asked if it has not also an effect on the yield. However, as the cloudiness is closely related to the rainfall it would be difficult, especially with the scanty material at hand, to separate the effect of each of these elements. It is possible, though, that the fact of the maximum yields having been obtained with rainfalls near the minimum is explained, because in these cases the plants have received more sunshine than when the rains have been more abundant.

SECULAR VARIATION OF THE YIELD.

The decennial means of the yield (Table 1) show a constant decrease in the last 30 years. It would be of interest to try and find out the causes of this diminution, and especially in connection with this study, if any change in the climate may be responsible for it.

In a study published in the *Monthly Bulletin* of the Argentine Meteorological Office corresponding to August, 1918, on the periods of drought and excessive rains, it was shown that the rainy periods had increased in the Republic in the last 30 years, and in the Province of Buenos Aires, excepting a relative diminution in 1890–1899, they have been constantly increasing since 1860. Notwithstanding this increase of the rainy periods, in the last years have also occurred periods of intense drought, so it seems that the climate has become more extreme, or the variations above and below normal are greater. These changes in the rainfall may doubtless have some influence on the yield of wheat, but as seen from the foregoing for this cereal the variations of temperature are more important than those of the rainfall.

Taking decennial means of the computed yields (Table 11) we get the following values:

	Kilograms per hectare.
1890–1899	757
1900–1909	703
1910–1919	699

It is seen that these also show a decrease, and as they are computed by means of the temperature, this shows that the average temperature has also changed, or at least the temperature of August to November has increased. We do not know, however, if this variation or that of the rainfall is a real change of climate, that is if it is permanent or if it results from some periodicity, and later that we will get back to the former condition.

The decrease in these computed averages is not as great as that observed according to Table 1. We may conclude therefore that the increase of temperature in spring is responsible for part of the diminution, but not for all. The change in the rainfall may in some part be to blame, but it is probable there are also other causes. One of these is doubtless the gradual extension of the cultivated area toward the west, where the winter rainfall often is insufficient. A proof of this is the fact that the average yield in Córdoba and the Pampa, where wheat growing on a large scale is relatively recent, is less than in Buenos Aires, Entre Rios, and Santa Fé. (See Table 5.)

In other countries the yield generally shows an increase, ascribed to improved methods of cultivation, and if in our country the application of scientific methods were more general, this factor would doubtless counteract those that tend to diminish the yield, and here also the yield would increase instead of decrease.

THE RAINFALL OF VENEZUELA.

By A. J. Henry.

[Weather Bureau, Washington, D. C., July, 1922.]

The editor has received from Señor Ernesto Sifontes, Venezuelan Meteorological Service, rainfall statistics for 1919–1921 for several stations in that country. It is possible now to bring up to date the record of rainfall for Caracas, originally published in 1911,[1] for each month of the period January, 1891, to December, 1910, and to complete the records for four other stations. The geographical coordinates of all the stations are given in the table next below and the monthly rainfall, in millimeters, is given in Table No. 2 following.

Table 1.—*Rainfall stations in Venezuela*[a]—*Geographical coordinates, etc.*

Stations.	Lat. N.		Long. W.		Elevation.	Length of record.	
						Years.	Months.
	°	′	°	′	*Meters.*		
Caracas	10	30	66	56	1,042	31	0
Mérida	8	36	71	9	1,641	6	8
Ciudad Bolívar	8	9	63	33	26	5	3
Calabozo	9	40	67	40	100	3	0
Maracaibo	10	35	71	45	6	3	0

[a] *See* C. E. P. Brooks in *Quart. Jour. Roy. Met. Soc.*, 48:71; also G. Hellmann in *Met. Zeit.*, December, 1921, pp. 375–376.

[1] Ugueto, Luis: *Revista Technica Del Ministerio De Obras Publicas*, 1911, p. 299.

Table 2.—*Rainfall (in millimeters) at the stations named.*

CARACAS.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual.
1911	1.5	25.5	6.4	40.0	93.0	152.8	153.9	174.8	44.4	61.3	85.5	39.1	878.2
1912	1.8	0	0	3.2	26.9	111.2	139.6	109.8	86.5	44.9	81.0	31.2	636.1
1913	44.9	0.8	13.6	0	53.6	78.3	63.3	90.3	113.6	73.5	87.9	44.5	664.3
1914	0	0	1.0	59.0	80.8	13.1	34.5	60.0	43.3	72.6	4.7	24.7	393.7
1915	19.5	48.1	0	123.5	52.7	129.4	77.0	118.2	110.5	120.1	23.5	5.6	828.1
1916	11.6	33.7	13.9	3.3	44.1	80.5	126.8	168.9	187.8	58.5	145.7	42.0	916.8
1917	15.5	14.7	6.3	52.4	34.3	192.6	155.1	77.6	90.2	60.6	29.3	101.9	830.5
1918	13.7	14.2	12.8	29.7	101.2	124.5	139.6	125.1	33.3	106.8	46.9	10.7	758.5
1919	0	0.3	23.2	113.0	32.1	122.8	63.9	102.5	108.1	95.9	123.1	4.7	789.6
1920	2.2	1.3	6.0	0	92.4	141.6	98.5	79.6	29.5	43.9	78.5	16.3	589.8
1921	25.1	0.3	33.5	16.9	59.1	230.2	95.1	147.9	151.6	141.8	146.7	90.7	1,138.9
Means[a]	21.7	9.7	16.8	42.8	71.0	108.5	111.6	108.6	91.8	96.2	84.2	45.8	808.9

MERIDA.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual.
1915	.....	.....	.....	.....	271.0	230.5	183.3	126.2	182.6	132.4	224.3	9.4	......
1916	104.8	74.5	131.3	130.7	95.4	235.1	83.7	239.3	132.7	449.8	233.6	53.4	1,964.3
1917	76.3	61.3	34.7	270.3	409.6	186.7	157.5	179.3	172.2	276.0	240.6	118.4	2,182.9
1918	48.0	40.6	79.1	141.5	445.6	185.8	105.7	84.5	133.1	240.3	278.6	43.2	1,826.0
1919	34.3	3.9	54.0	287.2	351.4	215.8	71.6	265.4	177.2	280.9	302.3	147.0	2,191.0
1920	67.7	46.8	88.3	100.8	255.0	144.2	74.8	93.7	164.2	157.1	52.7	37.3	1,282.6
1921	154.6	33.2	197.4	160.2	376.8	88.9	116.2	145.6	122.2	338.2	147.4	68.3	1,949.0
Means	80.9	43.4	97.5	181.8	315.0	183.9	113.3	162.0	154.9	267.8	212.8	68.1	1,063.0

[a] From the full record of 31 years, 1891–1921.

TABLE 2.—*Rainfall (in millimeters) at the stations named*—Continued.

CIUDAD BOLIVAR.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual.
1917	8.5	0	4.5	0.5	65.1	56.7	183.2	280.6	93.3	21.9	65.1	24.2	803.6
1918	20.4	9.1	11.9	25.4	93.9	167.2	122.8	93.2	13.8	125.8	252.7	36.6	972.8
1919	5.2	0	12.4	155.1	135.0	124.8	147.0	194.6	136.3	59.3	39.8	32.5	1,042.0
1920	13.5	11.6	2.2	1.8	90.1	143.3	121.8	108.1	120.0	88.9	71.5	52.0	824.8
1921	0.8	2.0	6.9	31.6	1.6	277.4	325.9	96.0	79.1	170.8	52.3	24.7	1,069.1
1922	25.8	1.6	3.1	.....	.....	.....	.....	.....	.....	.....	.....	.....	....
Means	12.4	4.0	6.8	42.9	77.1	153.9	180.1	154.5	88.5	93.3	96.3	34.0	943.8

CALABOZO.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual.
1919	0	0	135.0	170.0	199.5	197.4	182.0	209.0	161.3	108.3	33.0	0	1,395.5
1920	0	0	0	3.5	91.0	99.5	270.0	198.0	198.8	156.0	61.0	0	1,077.8
1921	0	132.9	41.0	177.0	69.0	204.6	273.6	226.8	66.9	66.8	64.3	0	1,322.9

MARACAIBO.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual.
1919	0	0	2.0	40.5	36.7	8.0	41.3	43.9	96.7	37.8	13.4	0.7	321.0
1920	0	1.7	3.0	0	91.7	84.0	48.5	25.5	100.4	105.1	16.3	2.3	478.5
1921	0	0	2.4	19.8	117.7	12.0	45.0	21.8	20.1	87.3	20.6	23.7	370.4

The statistics of the above table show that at least two distinct types of rainfall prevail in Venezuela, first the type exhibiting two well-marked maxima, the principal one occurring in May, the second and inferior one in October. The principal dry season falls in winter and the lesser one in July and August. This type is represented by the station Merida, in the mountain region of the northwest; a similar type prevails in Colombia to the westward, especially near the Equator. The second Venezuelan type is represented by the elevated station of Caracas the capitol of the Republic and also by Bolivar on the Orinoco, about 200 kilometers from its mouth. The characteristics of this second type are a principal maximum in summer (northern) and a secondary maximum in autumn. The dry season falls in winter. Figure 1 shows the two types very clearly.

The amount of rain which falls on the lowlands of Venezuela is never very great, even at Caracas, elevation 1,042 meters (3,419 feet), the greatest rainfall in 31 years being 1,202.9 mm. in 1892 (47.36 inches). About double that amount may fall in the higher regions of the mountains of western Venezuela. The greatest annual amount for example at Merida, 6 years observations, was 2,182.9 mm. Places at sea level and also in the interior have relatively small amounts, thus Maracaibo on the lake of the same name on the average of 3 years has but 390 mm. (15.35 inches). January and February at that station and also at Calabozo are sometimes without measurable rain. (See Table 2.) Many more observations are necessary however before conclusions can be confidently put forward.

The annual flood in the Orinoco.—Señor Sifontes has also supplied us with summaries of two annual floods in the river above mentioned. The details follow. Flood of 1918: The river began to rise April 11 and the rise ended August 13; the total rise was 12.21 meters (40.03 feet); the river then fell slowly until March 23, 1919, at which time the total fall amounted to 13.73 meters (45.03 feet). The total rise in the 1919 flood amounted to 14.74 meters (48.4 feet). The flood ended on August 23.

NORMALS FOR BRAZILIAN STATIONS.

The new Meteorological Service attached to the Brazilian Ministry of Agriculture, Industry, and Commerce, established in May, 1921, under the direction of Dr. J. de Sampaio Ferraz, has just issued a valuable collection of climatic normals for that country.[1]

This publication, which was compiled by Meteorologists H. Silva and L. Rodrigues, contains daily normals of the principal climatic elements for Rio de Janeiro, based in part on records for the 39 years 1882–1920, though the data for some elements are derived from shorter periods.

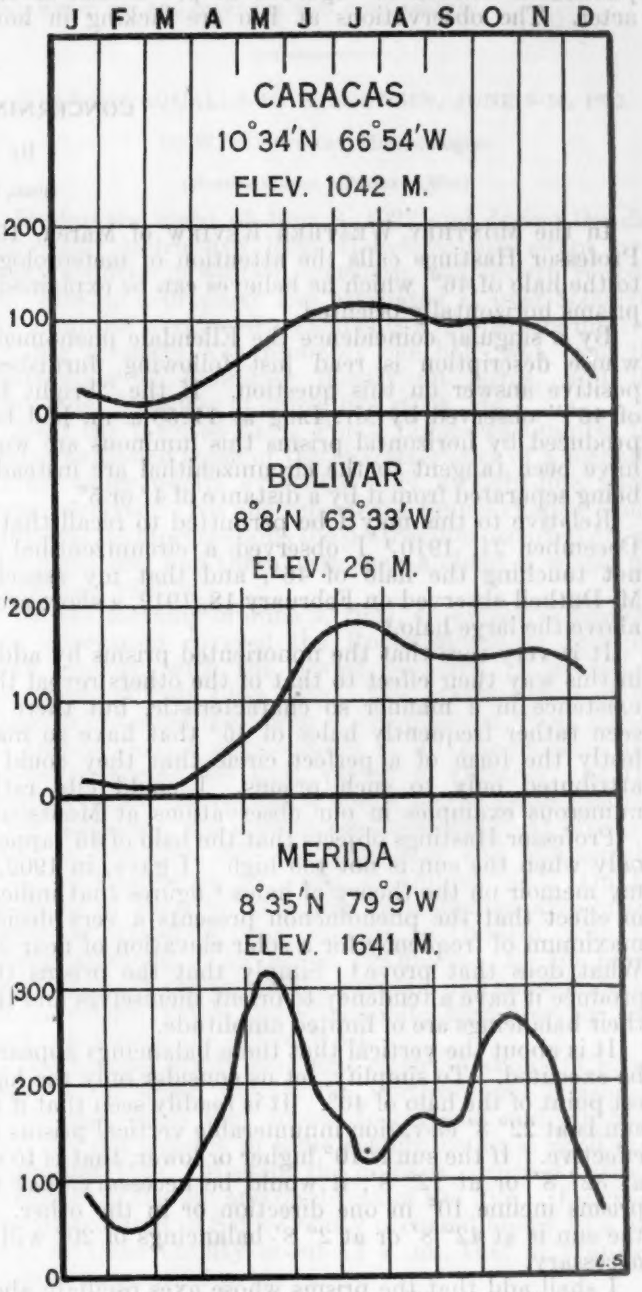


FIG. 1.—Monthly rainfall distribution at Venezuelan stations.

Monthly values of various elements are also given year by year for the total period available. The second half of the work contains monthly normals for the stations belonging to the National Meteorological Service, based chiefly on data for the whole or a part of the decade ending 1919.

In the preface the director states that on its establishment the new service was confronted with the formidable

[1] Brazil. Directoria de meteorologia. Boletin de normaes. Observações meteoro logicas feitas no ex-Observatorio nacional, hoje Instituto central, do Rio de Janeiro, e nas estações da rêde nacional. Campos: Officinas graphicas. 1922.

task of bringing up the arrears of the annual bulletins of meteorological observations which began and ended with the bulletin for the year 1910, published in 1914 by the former Directoria de Meteorologia e Astronomia. Before beginning the publication of this extensive series it was thought best to prepare the collection of normals which has just appeared. He states that the publication should be regarded as provisional in character. The observations at Rio are lacking in homogeneity on account of various methods of exposure and observation, and in any case it is difficult to obtain representative data for that city on account of its extremely irregular topography. The observations at field stations were taken by comparatively untrained observers in most cases. Nevertheless this publication is a noteworthy contribution to the climatology of Brazil, furnishing a more comprehensive collection of normals than has heretofore appeared for that part of the world.—*C. F. T.*

CONCERNING THE HALO OF 46°.

By LOUIS BESSON.

[Paris, France, June 26, 1922.]

In the MONTHLY WEATHER REVIEW of March, 1922, Professor Hastings calls the attention of meteorologists to the halo of 46°, which he believes can be explained by prisms horizontally oriented.

By a singular coincidence the Ellendale phenomenon, whose description is read just following, furnishes a positive answer on this question. If the "bright halo of 46°" observed by Mr. Ling at 11:58 a. m. had been produced by horizontal prisms this luminous arc would have been tangent to the circumzenithal arc instead of being separated from it by a distance of 4° or 5°.

Relative to this may I be permitted to recall that on December 21, 1910,[1] I observed a circumzenithal arc not touching the halo of 46°, and that my associate M. Dutheil observed on February 18, 1912, a short arc 3° above the large halo.[2]

It is very rare that the nonoriented prisms by adding in this way their effect to that of the others reveal their existence in a manner so characteristic, but there are seen rather frequently halos of 46° that have so manifestly the form of a perfect circle that they could be attributed only to such prisms. I could cite rather numerous examples in our observations at Montsouris.

Professor Hastings objects that the halo of 46° appears only when the sun is not too high. I gave, in 1909, in my memoir on the theory of halos [3] figures that indicate in effect that the phenomenon presents a very decided maximum of frequency for a solar elevation of near 20°. What does that prove? Simply that the prisms that produce it have a tendency to orient themselves and that their balancings are of limited amplitude.

It is about the vertical that these balancings appear to be executed. To simplify, let us consider only the highest point of the halo of 46°. It is readily seen that if the sun is at 22° 8′ elevation innumerable vertical prisms are effective. If the sun is 10° higher or lower, that is to say at 32° 8′ or at 12° 8′, it would be necessary that the prisms incline 10° in one direction or in the other. If the sun is at 42° 8′ or at 2° 8′ balancings of 20° will be necessary.

I shall add that the prisms whose axes oscillate about the horizontal contribute to the production of the halo of 46° when the sun is slightly elevated, but they bring forth especially the lateral parts, while the prisms near the vertical give the upper part.

Most often, but not always, the persistent existence of the maximum of intensity, whether above or at the side, betrays the tendency of the generating crystals toward a definite orientation. This remark is not peculiar to the halo of 46°. It is true also of the halo of 22°, for all observers know that of it there is seen especially the culminating part or the segments at the elevation of the sun.

It can happen that there is taken for an arc of the halo of 46° a supralateral tangent arc or an arc bitangent to this halo, the coloring being of the same order as that of the halo, from which they are usually difficult to distinguish.

At Montsouris in the first years we sometimes must have made this error, all the more pardonable in that there was not yet certainty as to the real existence of these tangential arcs foreseen by the intuition of Bravais. However, their reality is no longer in doubt, and we have learned to recognize them rather well even when they are very short by their colors, which are more vivid than those of the halo of 46°, and by the accompanying appearance of the tangential arc of 22°. The possibility of a mistake in this regard does not preclude the fact that just as there is a halo of 22° there is also a circular halo of 46° produced by prisms of 90°, whose position is near that of the minimum of deviation in accord with the old explanation by Cavendish.

I find in my notes figures showing under what conditions there appeared 79 halos of 46° observed at Montsouris from 1898 to 1908. It is, perhaps, not without interest to reproduce them here.

Phenomena visible at the same time as the halo of 46° or a little previous.

	Per cent.
Halo of 22°, not brilliant, alone	30
Halo of 22°, brilliant, or rather brilliant, alone	27
Parhelia	13
Tangential arcs of 22°, with parhelia	11
Tangential arcs of 22°, without parhelia	11
No phenomena	5
No definite indications	3

When the halo of 46° accompanies a halo of 22° that is brilliant and uniformly so, it may be asked if it is not produced "secondarily" by two successive refractions in prisms of 60°. Its radius would then be 44°. Among our numerous measurements there were three that gave this result, but correctness was not certain.

This is a point to which I take the liberty of directing the attention of observers.

[1] *Annales de l'Observaroire de Montsouris.* Tome XI, p. 47.
[2] *Loc. cit.* Tome XII, p. 241.
[3] *Loc. cit.* Tome X, p. 186.

TORNADOES IN WISCONSIN.

By W. P. STEWART, Meteorologist.

[Weather Bureau, Milwaukee, Wis.]

June 15, 1922.—During the evening of June 15, 1922, a destructive thunder squall and tornado swept over parts of four counties in northwestern Wisconsin, causing the loss of eight lives, injuries to about 100 persons, and property damage estimated at $500,000.

The weather map, based on the 7 p. m. observations of that date, shows an area of low pressure central over southern Minnesota, the lowest sea-level pressures reported being 29.60 inches, at Minneapolis and Moorhead. To the eastward in the St. Lawrence Valley there was a weak area of high pressure, 30.16 inches at Alpena. At Moorhead, Minneapolis, and Dubuque the wind was light southeast, the current temperatures being 74°, 78°, and 86°, respectively. At Duluth the wind was northeast, 20[1] miles, and the temperature was 50°. It will be seen from the foregoing that conditions were highly favorable for severe local squalls in the region south of Lake Superior.

The tornado originated a few miles north of the town of Roberts, which is slightly southwest of the center of St. Croix County, Wis., and traveled approximately northeast, passing close to the junction of Dunn and Polk Counties, and thence about east-northeast across southern Barron County to the vicinity of Chetek, where it was last reported.

Reports differ as to the exact time of the passage of this storm, but evidently it first was felt, near Roberts, about 7 p. m., and disappeared, near Chetek, about 9 p. m. As the length of the path was approximately 40 miles, the storm as a whole traveled only about 20 miles an hour.

The width of the path of great destruction varied from a few rods to two miles or more. In places along the path, particularly in western Barron County, destruction occurred over an area approximately 15 miles wide. It seems evident that in the wider portions of the storm's path much of the damage was caused by a severe thunder squall, rather than by the tornado proper. The characteristic funnel-shaped tornado cloud was reported from many points, but there were several observers in different localities who failed to see it.

The greatest destruction occurred in northeastern St. Croix County and in southern Barron County, but there was considerable damage in northwestern Dunn County and in southeastern Polk County. The property loss was extremely heavy in Forest Township, St. Croix County, and probably nearly as heavy in Vance Creek Township, Barron County. The greater part of the storm track was through a thinly settled region; otherwise the damage would have been much greater.

Fatalities reported were as follows: One in Polk County, two in St. Croix County, and five in Barron County.

Approximately 100 houses and barns were destroyed, much live stock was killed by wind and lightning, and a wide extent of crops were injured, in many cases the loss being complete. More or less serious damage was reported from the towns of Arland, Chetek, Deer Park, Emerald, Erin, Forest, Hammond, and Vance Creek.

It is belived a conservative estimate of the property loss is $500,000, probably three-fourths of which represents buildings destroyed, mostly on farms, and the remainder loss of crops, live stock, etc.

Tornado near Antigo.—At 2:30 p. m., June 16, 1922, a tornado passed from southwest to northeast about 2 miles west of Antigo, Langlade County, Wis., destroying about 10 farm buildings, many trees, and some live stock. No fatalities nor personal injuries were reported. The loss of buildings, live stock, etc., is conservatively estimated at $50,000. The damage to crops was not great. This was a real tornado, although a very brief one, the funnel-shaped cloud being reported by all observers. The width of the path of great destruction was 10 to 20 rods and its length about 1½ miles. Extensive inquiry fails to find any trace of this storm at any other point. The following note is from a report by the postmaster at Bryant, Wis., about 8 miles northeast of Antigo:

> The tornadic part of the storm was west of Antigo, although it blew hard here at Bryant without doing any damage of consequence. The tornado looked like it reached up about 1,000 feet or more in the air, with a width of about 10 to 20 rods on the ground decreasing to a narrow strip higher up, and revolving with great velocity.

[1] Doubtless due to the local topography at the Weather Bureau station.—EDITOR.

THUNDERSQUALLS IN WISCONSIN, JUNE 9–10, 1922.

By W. P. STEWART, Meteorologist.

[Weather Bureau, Milwaukee, Wis.]

During the night of June 9, 1922 and during the day following, destructive local thundersqualls swept over many counties in western, southern, and eastern Wisconsin, causing a property loss estimated at over $500,000. No fatalities were reported and only a few persons injured. Of the property loss probably one half was from the destruction of buildings, mostly on farms, and the remainder from loss of crops, live stock, etc.

Near the town of Eagle Point, Chippewa County, the storm exhibited some of the characteristics of a tornado; at all other points evidently only straight-line winds were involved. No one reported a funnel-shaped cloud. However, in most sections the destruction occurred during the night and had there been such a cloud it would not have been visible.

On the morning of June 9, 1922, an extensive barometric depression covered the Rocky Mountain and plateau regions, with the lowest pressure, 29.56 inches, sea level, at Salt Lake City. The evening map of the same day showed the center of low pressure, 29.42 inches, at Denver, and a development of the low-pressure area eastward across the Lake region to Ontario. At this time, 7 p. m., there was a sharp temperature gradient over Wisconsin, the current readings being: At Madison, 80°; at Dubuque, 82°; at Milwaukee and Minneapolis, 70°; at Marquette, 50°, and at Duluth, 44°. On the morning of June 10 there was an elongated area of low pressure extending from Arizona to Ontario, with the lowest pressure, 29.54 inches, at Omaha. By the morning of the 11th the area of low pressure had passed into the St. Lawrence Valley and a moderate high-pressure area had overspread the entire West.

Destructive winds were first reported about 11 p. m., June 9, in Dunn County, in northwestern Wisconsin. From that point they spread to the east and southeast and did not subside in some eastern counties until midnight the 10th. Most of the damage occurred between midnight of the 9th and daybreak of the 10th. However, the destruction in Sauk County occurred about 10 a. m.; that in Dane County about 11 a. m., that in Waupaca County not until 3 p. m.

The property loss in Chippewa and Dunn Counties was extremely heavy, the estimate of one reporter being $300,000 for Chippewa County alone. The damage was nearly as great in Jackson, Sauk, Green Lake, and Fond du Lac Counties, and there was serious loss in Eau Claire, Dane, Jefferson, Waupaca, Winnebago, and Calumet Counties. Following is a description of the storm at Eagle Point, Chippewa County, as given by Mr. C. L. Richardson of Chippewa Falls:

> The storm apparently had none of the features of the western tornado, but rather resembled the thunderstorm, marked only by unusual intensity of the wind. It advanced broadside across the country,

sweeping most of Chippewa County. Friday was warm, but cooler than the preceding or following days; air, damp. About 11:30 p. m. the wind blew from the northeast with a velocity of 15 to 20 miles an hour. The clouds seemed blackest in the northwest, but the lightning came up from the southwest. The wind backed from northeast to southwest from 11:30 p. m. to 11:50 p. m. At that time I estimated from 100 to 150 flashes of lightning per minute. The wind increased, veering to the west and northwest, and rose to 40 miles or more I should judge, with pauses and more violent blasts. Three, or perhaps four of the most violent gusts of wind, lasting one to two minutes each, occurred just before midnight, the worst about 11:57 p. m. This prostrated trees and buildings, laying them east, about 5° to 8° south. Two minutes later, and lasting about two minutes, the wind blew violently from the southeast, directly reversed, and then veered rapidly south, southwest, and west, where it remained. Rain fell heavily all of this time, seeming to reach a climax about 12:05 a. m. The lightning was continuous, but the thunder was high and distant. Only two or three fires were caused by lightning. The hail was unusual, varying from small stones to cases, seemingly verified, of masses of ice, square, triangular and jagged, as large as a man's fist. One mass of ice is said to have been a foot square and to have weighed between 20 and 30 pounds. I have some woods traversed by three "windfalls" 2 to 10 rods wide. Some of the trees are twisted with the watch hands. On the north side the trees fell south; otherwise they are east-southeast.

CONCUSSIONS FROM NAVAL GUNFIRING FELT AT LOS ANGELES.

RAYMOND A. NELSON, Meteorologist.

[Los Angeles Chamber of Commerce, Apr. 25, 1922.]

The United States Navy seems to have chosen southern California waters for regular battle practice of the Pacific Fleet, the ships running from Los Angeles Harbor, their home, to a point 20 to 30 miles from the coast or off Santa Catalina and San Clemente Islands. This gives the ships a position 30 to 40 miles south to southwest of Los Angeles.

Frequently when the ships are at practice, concussions are felt in Los Angeles but with varying intensities. When the ships are firing, it is common to notice faint vibrations of windows and doors, but sometimes the vibrations reach such proportions that nearly everyone immediately says "earthquakes." Shocks of "earthquake" proportions took place on the evenings of January 17 and March 23, 1922, during night target practice. Papers over the country gave out wild reports following the first date; college professors in other parts of the State said it was impossible for the shocks to be felt as far as Los Angeles and that they were earthquakes. Seismographs throughout the State of California recorded no movements on that date and the MONTHLY WEATHER REVIEW for January reports that earthquakes were felt in California from the 26th to the 31st only and these mostly in the northern part of the State except for shocks felt in Imperial Valley where earthquakes are frequent.

I have studied earthquakes somewhat and made a complete record of the shocks that occurred in southern California during the summer of 1920 and at the instant of the shock of January 17 I timed it and tried to get a duration and direction. Nothing was moving, such as chandeliers, pictures, or other hanging articles, and yet the windows and doors rattled as loud as during an earthquake of intensity 6 or 7. Sixty seconds passed and another shock, then another, and at regular intervals for half an hour or so. There was absolutely no floor movement or other vibration except for the rattle of windows. This same condition occurred again on the evening of March 23 and at the same time. The reason for these great atmospheric waves affecting Los Angeles seems to be a question of pressure distribution and the meteorological elements resulting.

It is a well-known fact that sound coming from some point may be heard more distinctly at certain times than at others. The distance at which the sound may be heard is also variable. The wind direction plays a most important part in this, in that if the sound-emitting body is in the direction from which the wind is blowing, the sound will be carried a greater distance. Sound waves traveling against the wind will be retarded.

The weather conditions during the evenings of January 17 and March 23 were practically the same. At both times an area of low pressure was central over Nevada and Utah, with a rather weak high-pressure area off the north Pacific coast. Under these conditions southern California would experience southwest winds with unsettled weather and considerable cloudiness. These normal conditions were taking place on the dates in question. The southwest wind was not only a surface wind but in effect at an elevation of over 6,000 feet. The sky was cloudy and these atmospheric waves were traveling with the wind as the ships were to the southwest of the city. The flashes were the result of star shells used by the ships to locate the "enemy." Under normal pressure conditions the valley in which Los Angeles is situated would be under the influence of the regular land and sea breeze—the sea breeze (southwest) during the day and the land breeze (northeast) at night. Had the low-pressure area over Nevada not been so strong and the regular northeast land breeze blowing, the shocks or concussions would have been very faint had they been noticed at all.

NOTES, ABSTRACTS, AND REVIEWS.

EXCHANGE OF METEOROLOGICAL REPORTS BY RADIO.

An agreement has been entered into whereby daily meteorological reports from 30 stations in the United States and Canada have been transmitted by radio since June 15, 1922, to the National Meteorological Service of France. These reports are broadcast through the Eiffel Tower on the day of receipt. In return, the United States Weather Bureau receives daily from the French Meteorological Service reports from 30 stations in Europe. In addition to the above, daily reports of weather conditions have been received almost daily since June 23, 1922, from Amundsen's polar expedition ship *Maud* and will continue to be received so long as the ship is within reach of American stations.

ABERDEEN AND BENSON.

[Excerpts from *Meteorological Magazine*, London, July, 1922.]

The past month is remarkable for the announcement of two retirements; that of Prof. Charles Niven, F.R.S., from the professorship of natural philosophy at Aberdeen, to which was attached the care (on behalf of the Meteorological Office) of the Meteorological Observatory at Kings College; and that of Mr. W. H. Dines, F.R.S., from the direction and management of the Aerological Observatory at Benson. * * *

Mr. W. H. Dines is also a link with the past. Devoted to the study of meteorology as a family tradition and endowed with all the qualifications that are implied by a training in mechanical engineering, a Wranglers' degree at Cambridge, long experience in teaching of mathematics, the habit of mind which sees what is there, no more and no less, and a personal knowledge of the ways of meteorology in society, he was exactly qualified to undertake the direction and management of an observatory for the upper air, and after some experience with kites at Oxshott, he took on charge the work on the Upper Air for the Meteorological Office in return for out-of-pocket expenses and a small honorarium which was not large enough to interfere with his sense of freedom. * * *

Mr. Dines's summary in the *Characteristics of the Free Atmosphere* [1] is remarkable evidence of personal achievement. Reference was constantly made to the facts and summaries given therein during the development of aircraft and engines. An appreciation of Mr. Dines's services to science and the State might very well be expressed otherwise, but he has at least the satisfaction of knowing that if the achievement of the maximum result with the minimum of cost is to be regarded as good service, none is better than his.

Mr. Dines began with the study of wind, went on to the upper air, and at the end of his official service finds himself embroiled in radiation. With his unwillingness to accept what he can not verify he is still busy with the distribution of temperature in the atmosphere. If he will recall what a crazy patchwork the science of meteorology was acknowledged to be when he began his active share in it in the "seventies" and how much he has contributed to making it a tissue with a pattern in it, he can not fail to find encouragement to pursue this study of radiation in his retirement, with the assurance that the interest which those who look on take in his work increases and will increase with his increasing years.—*Napier Shaw.*

[1] *Geophysical Memoir* No. 13, M. O. 220c, 1919.

4829—22——3

EVAPORATION AND PRECIPITATION ON THE EARTH.[1]

By DR. GEORG WÜST.

[Abstracted from *Zeitschrift der Gesellschaft für Erdkunde zu Berlin*, No. 1-2, 1922.]

Accepting the values for precipitation, run-off, and evaporation given by Fritzsche [2] for the region between 60° N. latitude and 40° S. latitude, and supplementing these by assigning values for the regions poleward, there is obtained for the total evaporation from the land 75,000 km³/year, or 50.4 cm./year, and for the run-off 37,100 km³/year. By introducing these values in Brückner's fundamental equation $R_e = V_e + F$ (precipitation on land equals evaporation on land plus run-off) the total precipitation on the land is found to be 112,000 km³/year, or 75.3 cm./year.

Relative to evaporation on the ocean two methods of determination are discussed. In the indirect method by W. Schmidt [3] there is determined from the different radiation energies the amount of heat available for evaporation and convection. An apportionment of this heat to the two processes gives a theoretical value for evaporation amount and with this there is obtained the probable reduction factor of 0.43 for reducing to sea surface the observations of evaporation made on ships. The direct method of comparison employed by the author showed that evaporation values at the sea surface are 44 per cent less than those observed on ships (elevation 6 meters); hence the reduction factor of 0.56, which is considered maximum. From a discussion of the influences surrounding the evaporation vessel 0.40 is assumed as minimum value of the factor, and it is written 0.48 ± 0.08. To the reduction factor 0.48 there corresponds an evaporation of 84 cm./year (limit of error 10 per cent).

Brückner [4] in his investigation of evaporation carried out for large basins and reservoirs found the value of 105 cm./year. According to Bigelow,[5] who by comparative measurements derived ratios for vessels of different sizes, even for these water surfaces a reduction factor proves necessary. From a tabular statement Bigelow's reduction factor for Brückner's values is found to be 0.82, and the amount 105 cm./year is reduced to 86 cm./year. The application of this value to oceanic evaporation assumes that relative to evaporation climatic conditions are the same on land and sea in the same zone. However, this is not the case; lower wind velocity over water surfaces of the land gives lower evaporation and lower vapor pressure over the same gives greater evaporation than at sea. Since the author was able to show [6] that these effects neutralize each other in large degree Brückner's values for free water surfaces of the land, when reduced, come comparatively near the true oceanic evaporation and lie within the limits previously given.

The value of 84 cm./year gives 304,200 km.³/year for oceanic evaporation. Introducing this in Brückner's fundamental equation $R_m = V_m - F$ (oceanic precipitation equals oceanic evaporation less run-off) we find 267,100 km.³/year for oceanic precipitation. This corresponds to 74.2 cm./year.

[1] *Verdunstung und Niederschlag auf der Erde.*
[2] *Niederschlag, Abfluss und Verdunstung auf den Landflächen der E. Diss.*, Halle, 1906.
[3] Strahlung und Verdunstung an freien Wasserflächen, ein Beitrag zum Wärmehaushalt des Weltmeeres und zum Wasserhaushalt der Erde. *Ann. d. Hydr. usw*, 1915.
[4] Die Bilanz des Kreislaufes des Wassers auf der Erde. *Geogr. Zeitschr.*, 1905.
[5] The laws of the evaporation of water from pans, reservoirs and lakes, sand, soil and plants. *Bulletin Argentine Meteorological Office*, 1912.
[6] Die Verdunstung auf dem Meere. *Veröff. d. Inst. f. Meereskunde.* N. F. Reihe A, Heft 6, 1920 (S. 85).

The zonal values found by von Kerner[7] lead to the "considerably too high" value of 363,240 km.³/year, or 100.6 cm/year for oceanic precipitation. Assuming that von Kerner's values render correctly the zonal distribution of precipitation at sea they are retained, but are reduced in the ratio 74.2 : 100.6 (factor 0.734).

Relative to the following table: "Even if the zonal amounts are only approximate values the final totals can yet lay claim to a high decree of probability. The zonal values are probably of value in many questions, since they are comparable among themselves."

TABLE 1.—*Zonal distribution of evaporation and precipitation on the earth (calculated on the basis of results of investigation by Fritzsche, von Kerner, and Wüst).*

OCEAN.

Zone.	Area[8] (10⁶ km.²).	Mean depth (cm./year).			Amounts in 1,000 km.³/year.	
		N[1]	V	$N-V$	N[8]	V
°N.—						
90–80	3.5	*(15)	*(5)	*(10)	*(0.5)	*(0.2)
80–70	8.2	(29)	(9)	(20)	(2.4)	(0.7)
70–60	5.6	48	12	36	2.7	0.7
60–50	10.9	96	40	**56**	10.4	4.4
50–40	15.0	**117**	70	47	**17.6**	10.5
40–30	20.8	51	96	−45	10.7	20.0
30–20	25.1	*22	115	*−93	*5.5	28.9
20–10	31.5	62	**120**	−58	19.7	**37.8**
10–0	34.0	**140**	*100	**40**	**47.5**	*34.0
°S.—						
0–10	33.7	95	114	−19	32.2	38.4
10–20	33.4	66	**120**	−54	22.2	**40.1**
20–30	30.9	*51	112	*−61	*15.9	34.6
30–40	32.3	88	89	−1	**28.6**	28.8
40–50	30.5	**92**	58	34	28.0	17.7
50–60	25.4	70	23	**47**	17.7	5.8
60–70	17.1	(29)	(9)	(20)	(5.0)	(1.5)
70–80	3.1	*(15)	*(5)	*(10)	*(0.5)	*(0.2)
80–90	0.0	0	0	0	0.0	0.0
90° N. to 90° S.	361.1	74.2	84.2	−10.0	267.1	304.2

LAND.

Zone.	Area[9] (10⁶ km.²).	Mean depth (cm./year).			Amounts in 1,000 km.³/year.	
		N[1]	V	$N-V=F$	N[8]	V
°N.—						
90–80	0.4	(34)	*(5)	(29)	*(0.1)	*(0.0)
80–70	3.4	*(26)	(9)	(17)	(0.9)	(0.3)
70–60	13.3	35	(12)	(23)	4.7	(1.6)
60–50	14.7	50	36	*14	7.4	5.3
50–40	16.5	51	33	18	8.4	5.5
40–30	15.6	52	38	14	8.1	5.9
30–20	15.1	79	50	29	11.9	7.6
20–10	11.3	95	79	16	10.7	8.9
10– 0	10.1	172	115	57	17.4	1.6
°S.—						
0–10	10.4	**181**	**122**	**59**	**18.8**	**12.7**
10–20	9.4	110	90	20	10.3	8.5
20–30	9.2	64	*41	23	6.0	3.8
30–40	4.1	*57	51	*6	2.3	2.1
40–50	1.0	87	(50)	(37)	0.9	(0.5)
50–60	0.2	**102**	(20)	(82)	0.2	*(0.0)
60–70	0.8	(30)	(10)	(20)	*(0.2)	(0.1)
70–80	8.5	(30)	(5)	(25)	(2.6)	(0.4)
80–90	3.9	*(30)	*(5)	(25)	(1.2)	(0.2)
90° N. to 90° S.	148.9	75.3	50.4	24.9	112.1	75.0

[7] Eine neue Schätzung des Gesamtniederschlages auf den Meeren. *Mitt. d. k. k. geogr. Gesellschaft in Wien.* Bd. 61, 1918.
[8] Van Kesner's zonal values reduced by the factor 0.734.
[9] Areas according to H. Wagner and E. Kossina.

TABLE 1.—*Zonal distribution of evaporation and precipitation on the earth (calculated on the basis of results of investigation by Fritzsche, von Kerner, and Wüst*—Continued.

ENTIRE EARTH.

Zone.	Area[9] (10⁶ km.²).	Mean depth (cm./year).			Amounts in 1,000 km.³/year.	
		N[1]	V	$N-V$	N[8]	V
°N.—						
90–80	3.9	*(17)	*(5)	(12)	*(0.6)	*(0.2)
80–70	11.6	(29)	(9)	(20)	(3.3)	(1.0)
70–60	18.9	(39)	(12)	(27)	7.3	(2.3)
60–50	25.6	69	38	31	17.8	9.7
50–40	31.5	**83**	51	**32**	**26.0**	15.9
40–30	36.4	51	71	−20	18.8	25.9
30–20	40.2	*43	91	*−48	*17.4	36.4
20–10	42.8	71	**109**	−38	30.5	**46.7**
10– 0	44.1	**147**	*103	**44**	**64.9**	*45.6
°S.—						
0–10	44.1	116	**116**	0	51.0	**51.2**
10–20	42.8	76	113	−37	32.5	48.5
20–30	40.2	*54	96	*−42	*21.9	38.4
30–40	36.4	85	85	0	**30.9**	30.8
40–50	31.5	**92**	58	34	28.9	18.2
50–60	25.6	70	23	**47**	17.9	5.9
60–70	18.9	(28)	(9)	(19)	(5.2)	(1.6)
70–80	11.6	*(26)	(7)	(19)	(3.1)	(0.6)
80–90	3.9	(30)	*(5)	(25)	*(1.2)	*(0.2)
90° N. to 90° S.	510.0	74.3	74.3	0.0	379.2	379.2

N, precipitation; *V*, evaporation; *F*, run-off.
Maxima in boldface type, minima with asterisks, hypothetical values in parentheses.

Attention is called to the following features shown in the table: (1) Secondary maximum of precipitation at sea in the zones of the variable winds (40° to 50° lat.) separated from the absolute maximum at the Equator by the extremely dry subtropics; (2) increase in evaporation equatorward interrupted at sea by secondary minimum in the "belt of calms"; (3) considerable excess (in cms.) of oceanic evaporation over land evaporation in subtropical and middle latitudes, values of the same magnitude for tropical latitudes; (4) difference in the amount $N-V$ on land and sea—excess of evaporation over precipitation on the sea at 10° to 40° N. latitude and at 0° to 30° S. latitude, decrease in $N-V$ (run-off) from the Equator not constant on the land, desert belts are recognizable.

The paper closes with the following comparative table:

Different determinations of the hydrology of the earth.

[Amounts in 1,000 km.³/year.]

	Precipitation.			Evaporation.		
	Fritzsche-Brückner.	Schmidt-Fritzsche.	Wüst-Fritzsche.	Fritzsche-Brückner.	Schmidt-Fritzsche.	Wüst-Fritzsche.
Ocean	353.4	242.4	267.1	384.0	273.0	304.2
Land	111.9	111.9	112.1	81.3	81.3	75.0
Earth	465.3	354.3	379.2	465.3	354.3	379.2

—*W. W. R.*

RETURN-FLOW WATER FROM IRRIGATION DEVELOPMENTS.[1]

By R. I. MEEKER, Irrigation Engineer, Denver, Colo.

The importance of Mr. Meeker's study of the disposal of irrigation water will be quickly recognized by all interests concerned in the development of irrigated areas. We reproduce Mr. Meeker's summary only as given in his own words:

Summary.—The following paragraphs summarize the conclusions of this study:

(1) Ordinarily 50 per cent of the water diverted for irrigation purposes becomes a source of return flow.

(2) Annual return flows of from 35 to 65 per cent of the river flow diverted have been measured for large compact irrigated areas.

(3) In the South Platte and tributary valleys in Colorado, where 1,100,000 acres are irrigated, return flow amounts to 1,000,000 acre-feet annually.

(4) In the Cache la Poudre Valley where irrigation is intensive and 250,000 acres are irrigated, the annual return flow is 130,000 acre-feet or about 0.50 acre-feet per acre.

(5) In the North Platte Valley, Nebr., where water is plentiful, the annual returns from 250,000 acres are 1.6 acre-feet per acre.

(6) Annual drainage returns on the two Colorado projects of 5,000 and 30,000 acres, respectively, fall close to 1 acre-foot per acre.

(7) Monthly returns throughout the year are not constant. The summer and fall months are the months of maximum return and the minimum returns occur in the winter and spring months.

(8) From 50 to 60 per cent of return flow under natural or artificial drainage occurs during the irrigation season and is available for re-use.

(9) Return-flow waters from irrigation in the older irrigated valleys are a large factor in water supply and have a large economic value.

[1] *Engineering News Record*, July 20, 1922.

THE RELATION BETWEEN HAZE AND RELATIVE HUMIDITY OF THE SURFACE AIR.

By J. WADSWORTH, M. A.

[Abstract from *Professional Notes No. 20*, British Meteorological Office, 1921.]

Mr. Wadsworth has made investigations of the records at various stations in England to discover if there is any relation between the occurrence of haze and the humidity of the air. At Eskdalemuir, Valencia, and Kew he found that there was a rapid decrease in the frequency of mist and an increase in the frequency of haze as the humidity decreased. The records at Aberdeen showed that both haze and mist tended to disappear in dry air. He accounts for the contradiction by probable confusion of the terms haze and mist or the presence of other causes.—*R. T. E.*

BIBLIOGRAPHY.

RECENT ADDITIONS TO THE WEATHER BUREAU LIBRARY.

C. FITZHUGH TALMAN, Professor in Charge of Library.

The following have been selected from among the titles of books recently received as representing those most likely to be useful to Weather Bureau officials in their meteorological work and studies:

Australia. Commonwealth bureau of census and statistics. Melbourne.
Official year book of the Commonwealth of Australia, containing authoritative statistics for the period 1901–1920, and corrected statistics for the period 1788 to 1900. No. 14. 1921. Prepared by G. H. Knibbs and completed by John Stonham. Melbourne. [1921.] xxxviii, 1228 p. diagr. maps. 24 cm. [Climate and meteorology of Australia, p. 54–81, with charts, tables, and graphs.]

Brazil. Directoria de meteorologia.
Boletim de normaes. Campos. 1922. viii, 68 p. 32½ cm. [Cf. this REVIEW, pp. 309–310.]

Čzechoslovakia. Státní ústav hydrologický.
Návod pro pozorování ovzdušných srážek. Praze. 1921. 17 p. plates. 25½ cm. (Sbírka příruček. Č. 2.)
Návod pro pozorování teploty vzduchu. Praze. 1921. 5 p. illus. 25 cm. (Sbírka přírecek. Č. 3.)
Návod pro sněhoměrná pozorování. Praze. 1921. 8 p. illus. 25. cm. (Sbírka příruček. Č. 4.)

Denmark. Meteorologiske institut.
Ugeberetning om nedbør. April-September, 1919–1921. Kjøbenhavn. 1919–1921. unp. 35 cm.

Hamburg. Deutsche Seewarte.
Resultate meteorologischer Beobachtungen von deutschen und holländischen Schiffen für Eingradfelder des Nordatlantischen Ozeans. Hamburg. 1921. v. 20. xxvi, 193 p. 31½ cm.

Letzmann, Johannes.
Die Höhe der Schneedecke im Ostbaltischen Gebiet. Dorpat. 1921. 65 p. illus. 24 cm.
Tromben in Ostbaltischen Gebiet. Dorpat. 1920. p. 7–46. plates. 23½ cm. (Extr.: Sitzungsberichten der Naturforscher-Gesellschaft, Universität Dorpat. Bd. 24. 1918/1919.)

Mexico. Secretaria de agricultura y fomento.
Carta de precipitacion anual (promedios de varios años.) Año de 1922. 48 x 61 cm.

Mohn, H.
Atlas de climat de Norvège. Nouvelle édition par Aage Graarud et Kristen Irgens. Kristiania. 1921. 5 p. 60 plates. 31 cm. (Geofysiske publikationer. v. 2. no. 7.)

Vanderlinden, E.
Observations phénologiques sur des végétaux. Bruxelles. 1922. 14 p. tables. plates. 27 cm. (Extr.: Recueil de l'Institut botanique Léo Errera. T. 10.)

Vegard, L.
Determination of the wave length of the green line of the auroral spectrum. Kristiania. 1922. 11 p. 31 cm. (Geofysiske publikationer. v. 2. no. 5.)

Zierl, Hermann.
Mond und Luftdruck. [Bibliography.] 13 p. 33 cm. (Extr.: Deutches meteorologisches Jahrbuch für Bayern. 1921.)

RECENT PAPERS BEARING ON METEOROLOGY AND SEISMOLOGY.

C. F. TALMAN, Professor in Charge of Library.

The following titles have been selected from the contents of the periodicals and serials recently received in the library of the Weather Bureau. The titles selected are of papers and other communications bearing on meteorology and cognate branches of science. This is not a complete index of all the journals from which it has been compiled. It shows only the articles that appear to the compiler likely to be of particular interest in connection with the work of the Weather Bureau.

American journal of science. New Haven. (5) v. 3. May, 1922.
Winchell, Alexander, & Miller, Eric R. The great dustfall of March 19, 1920. p. 349–364.

American meteorological society. Bulletin. Worcester, Mass. v. 3. 1922.
Brooks, C. F., & Donnelly, E. C. A scale of weather values with graph showing daily sequence of the weather. p. 63. Abstract. [April.]
Crump, M. H. Cave air versus torrid temperature. (By title.) p. 63–65. (April.)
Hoffman, F. L. Climate and health in the South American tropics. p. 65–66. (April.)
Humphreys, W. J. How fast can a droplet grow by falling in a cloud? p. 59–60. [Abstract.] (April.)
McAdie, Alexander. Comment on review of Redway's Handbook of meteorology. (By title.) p. 60–62. [Discussion of meteorological units.] (April.)
Reed, William Gardner. Military meteorology. p. 57–59. [Abstract.] (April.)
Bowie, E. H. The formation and movement of West Indian hurricanes. p. 95–96. [Abstract.] (June.)

American meteorological society. Bulletin. Worcester, Mass. v. 3. 1922—Continued.
Humphreys, W. J. A contributing factor in the mechanism of tropical cyclones. p. 96. [Abstract.] (June.)
Pearson, S. K., jr. Local value of the cooperative observer's work. p. 85–86. (June.)
Shepard, Cola W. Co-ops should study climate. p. 84–85. (June.)
Sonnedecker, T. H. An appreciation of the duties of a cooperative observer. p. 87–88. (June.)
Sullivan, Richard H. Veteran observers and old weather records. p. 87. (June.)
Woolard, Edgar W. Recent contributions to mathematical meteorology. p. 96–98. [Abstract.] (June.)

Astrophysical journal. Chicago. v. 55. June, 1922.
King, Arthur S. Note on the thickness of air required to produce the atmospheric absorption bands, A, a, and B. p. 411–412.

Aviation. New York. v. 12. June 26, 1922.
Winters, S. R. Air service tests new instruments. Rate of climb indicator, bubble statoscopes, and new barograph tested in balloon flights. p. 755–756.

Engineering news-record. New York. v. 88. June 29, 1922.
Houk, Ivan E. Hydraulic design of bridge waterways. p. 1071–1075. [Includes discussion of cloudbursts.]

Engineering news-record. New York. v. 89. July 13, 1922.
Hazen, Allen. Effect of elevation upon run-off from catchment areas in New Jersey. p. 62–64.

France. Académie des sciences. Comptes rendus. Paris. t. 174. 19 juin 1922.
Rateau, A. Pressions et poids spécifiques de l'air en atmosphère normale. p. 1598–1604.

Gesellschaft für Erdkunde zu Berlin. Zeitschrift. Berlin. 1922. No. 1–2.
Wüst, Georg. Verdunstung und Niederschlag auf der Erde. p. 3543. [Abstract in this REVIEW, p. 313.]

Great Britain. Meteorological office. London. Monthly meteorological charts. North Atlantic ocean, 1922.
Hennessy, J. Atmospheric obscurity at Thames estuary and approaches. (July.)
Howard, A. G. W. Clouds and weather charts. (August.)

Hemel en Dampkring. Den Haag. 20. Jaarg. Juni 1922.
Everdingen, E. Van. Metigen van den boog van Lowitz en andere optische verschijnselen op 10 Maart 1922. p. 39–45.

India. Meteorological department. Memoirs. Calcutta. v. 22, pt. 7. 1921.
Normand, C. W. B. On dust-raising winds.

Japan. Imperial earthquake investigation committee. Bulletin. Tokyo. v. 10, no. 1. March, 1922.
Omori, F. The Omachi (Shinano) earthquakes of 1918. 1. p. 1–41.

Japan. Imperial earthquake investigation committee. Seismological notes. Tokyo. v. 10. no. 2. March, 1922.
Omori, F. On the severe earthquake of Dec. 8, 1921. p. 1–21.
Yasuda, Ch. List of the after-shocks of the earthquakes of Dec. 8, 1921. p. 22–23.

Meteorologische Zeitschrift. Braunschweig. Bd. 39. Mai 1922.
Beer, Arthur. Die Polarlichter vom 13 und 15. Mai 1921. p. 144–147.
Exner, F. M. Das erste Beobachtungsjahr auf der steiermärkischen Sonnenhellstätte Stolzalpe. (1200 m.) p. 149–152.
Gehlhoff, Kurt. Thermoelektrische Messung des nächtlichen Temperaturverlaufes in den unteren Luftschichten. p. 137–141.
Kähler, K. Die Schattenhelligkeit an wolkenlosen Tagen und ihre Beziehungen zur Gesamthelligkeit. p. 132–136.
Reger, J. Die Herkunft der Niederschläge in Norddeutschland. p. 141–144.
Schmauss, A. Eine Tagesperiode der aperiodischen Druckschwankungen. p. 155.
Wegener, Kurt. Depression und Taifun. p. 129–132.

Nature. London. v. 109. May 20, 1922.
Oldham, R. D. The cause and character of earthquakes. p. 650–653.

Nature. Paris. 50, année. 10 juin 1922. Supplément.
M., R. La mortalité et la météorologie. p. 186. [Abstract of memoir by L. Besson.]

Naturwissenschaften. Berlin. 10 Jahrg. 26 Mai 1922.
Kuhlbrodt, Erich. Über die Polarfronttheorie nach Bjerknes und die neueren Anschauungen von den atmosphärischen Vorgängen. p. 495–503.

Paris. Services techniques d'hygiène. Annales. t. 2. 1921.
Besson, L. Relations entre les éléments météorologiques et la mortalité. p. 181–206.

Physico-mathematical society of Japan. Proceedings. Tokyo. v. 4. June, 1922.
Terada, Torohiko. On resultants of wind. p. 125–133.

Reale accademia dei Lincei. Atti. Roma. v. 39. 1922.
Eredia, Filippo. L'influenza del monte Etna sulle correnti superiori. p. 251–254.

Royal society of London. Proceedings. London. Ser. A. v. 101. July 1, 1922.
Rayleigh, Lord. A study of the presence or absence of nitrogen bands in the auroral spectrum. p. 312–315.
Thomson, J. J. On the analysis by positive rays of the heavier constituents of the atmosphere; of the gases in a vessel in which radium chloride had been stored for 13 years, and of the gases given off by deflagrated metals. p. 290–299.

Royal statistical society. Journal. London. New ser. v. 85. May, 1922.
Beveridge, Sir William H. Wheat prices and rainfall in Western Europe. p. 412–478.

Scientific American. New York. v. 127. July, 1922.
The airman's weather-finder. p. 35.
Dacy, George H. Earthquake detection near the White House. p. 31.
The statistics of climate. A vast but strikingly inadequate body of scientific data. p. 21; 70.
Tamed lightning. Dr. Steinmetz' small-scale duplication of nature's discharge. p. 26.

Scientific monthly. New York. v. 15. July, 1922.
Douglass, A. E. Some aspects of the use of the annual rings of trees in climatic study. p. 5–21.
Visher, Stephen Sargent. Variability vs. uniformity in the tropics. p. 22–34.

Sirius. Leipzig. Bd. 55. 1922.
Freybe, O. Mond und Wetter. p. 61–62. (April.)
Schmid, F. Die Beziehungen der Abend- und Morgendämmerung zum Zodiakallichte. p. 95–100. (Mai/Juni 1922.)

Sociedad científica "Antonio Alzate." Memorias y revista. México. Tomo 39. Julio y agosto, 1921.
Ordóñez, E., & Larios, H. Las nubes de polvo sobre la ciudad de México. p. 475–479.

Sociedad científica "Antonio Alzate." Memorias y revista. México. Tomo 40. Enero a junio, 1922.
López, Elpidio. Climatología de la República Mexicana. p.109–144.

South African irrigation dept. magazine. Pretoria. v. 1. October, 1921.
Stewart, C. Rainfall and river notes from a Karroo farmer's diary; Colonies Plaats: 1883–1902. p. 15–18.
Van Warmelo, W. Hydrographic statistics. 1911–1919. Mean rainfall. Run off. Relation between rainfall and run off. p. 32–34.

SOLAR OBSERVATIONS.

SOLAR AND SKY RADIATION MEASUREMENTS DURING JUNE, 1922.

By HERBERT H. KIMBALL, in Charge, Solar Radiation Investigations.

For a description of instruments and exposures, and an account of the method of obtaining and reducing the measurements, the reader is referred to this REVIEW for April, 1920, 48 : 225.

From Table 1 it is seen that direct solar radiation intensities averaged slightly below the normal for June at all three stations.

Table 2 shows that the total solar and sky radiation received on a horizontal surface averaged below the June normal at Washington. At Madison it averaged above the normal during the first half of the month and below during the second half.

Skylight-polarization measurements made on two days at Washington give a mean of 44 per cent with a maximum of 51 per cent on the 12th. These are slightly below the respective averages for June. At Madison, measurements made on nine days give a mean of 53 per cent with a maximum of 71 per cent on the 3d. The

mean is below and the maximum above the respective average of these data for June.

TABLE 1.—*Solar radiation intensities during June, 1922.*

[Gram-calories per minute per square centimeter of normal surface.]

Washington, D. C.

Date.	Sun's zenith distance.										
	8 a.m.	78.7°	75.7°	70.7°	60.0°	0.0°	60.0°	70.7°	75.7°	78.7°	Noon.
	75th meridian time.	Air mass. A. M.					P. M.				Local mean solar time.
	e.	5.0	4.0	3.0	2.0	*1.0	2.0	3.0	4.0	5.0	e.
	mm.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	mm.
June 12	12.24	0.63	0.73	0.86	1.03	1.25					9.47
22	12.24		0.63								9.47
23	7.87					1.35					8.48
30	17.37			0.49	0.73	1.07					17.37
Means		(0.63)	(0.68)	(0.68)	(0.88)	1.22					
Departures		+0.14	+0.02	−0.08	−0.03	−0.04					
Madison, Wis.											
June 1	8.81			1.03	1.18	1.35					7.04
3	8.81				1.20	1.37					8.81
5	11.38				0.86						10.59
7	12.24				0.82	1.06					10.59
12	12.24			1.04	1.23						9.14
14	14.60				1.13	1.33					11.38
23	11.38				0.91	1.23	0.91				15.11
27	12.24				1.09	1.35					11.81
29	12.68			0.75	0.85						12.68
Means				0.94	1.03	1.28	(0.91)				
Departures				−0.02	−0.08	−0.02	−0.15				
Lincoln, Nebr.											
June 2	8.18		0.65		0.92						7.87
3	8.81		0.57		0.96						8.48
6	12.68			0.85	1.05	1.30					10.97
7	13.61		0.65	0.80	1.01	1.31					11.81
13	15.65					1.16	0.90	0.76	0.66		18.59
15	13.13			0.87	1.04	1.25					14.10
17	12.24			1.05		1.40	1.21	1.05	0.91		11.38
20	12.24		0.68	0.83	1.07	1.40	1.04	0.78			9.47
22	12.24		0.77	0.91	1.08	1.32	0.99	0.80	0.65		10.97
23	13.61		0.70	0.85	1.03	1.27	0.89	0.70	0.58		11.81
26	12.68					1.35	1.02	0.77	0.59		13.61
Means			0.67	0.88	1.02	1.31	1.01	0.81	0.68		
Departures			−0.07	−0.06	−0.05	−0.04	−0.08	−0.09	−0.08		

* Extrapolated.

TABLE 2.—*Solar and sky radiation received on a horizontal surface.*

Week beginning—	Average daily radiation.			Average daily departure for the week.			Excess or deficiency since first of year.		
	Washington.	Madison.	Lincoln.	Washington.	Madison.	Lincoln.	Washington.	Madison.	Lincoln.
	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.
May 28	469	494		−25	+4		−1,891	−1,561	
June 4	469	554		−31	+50		−2,107	−1,208	
11	470	514		−43	−5		−2,408	−1,242	
18	510	495		−11	−38		−2,486	−1,511	
25	433	513		−30	−27		−2,699	−1,699	

MEASUREMENTS OF THE SOLAR CONSTANT OF RADIATION AT CALAMA, CHILE.

By C. G. ABBOT, Assistant Secretary.

[Smithsonian Institution, Washington, August 3, 1922.]

In continuation of preceding publications, the following table contains the results for the solar constant of radiation obtained at Montezuma, near Calama, Chile, in April and May, 1922. The values of ρ/ρ sc are given at air mass 2, or if not the air mass is stated. The reader is referred for further statements regarding the arrangement and meaning of the table to the REVIEW for February, August, and September, 1919.

Date.	Solar constant.	Method.	Grade.	Transmission coefficient at 0.5 micron.	Humidity. ρ/ρ sc.	V. P.	Relative humidity.	Remarks.
1922.	cal.					cm.	Per cent.	
A. M. Apr. 5	1.916	$M_{2.20}$	S.	0.887	[1] 0.547	0.40	24	Some cirri in east and north; near sun during second bolograph.
	1.929	$M_{1.81}$						
	1.936	$M_{1.46}$						
	1.929	W. M.						
P. M. Apr. 6	1.891	$M_{2.5}$	S.	.884	.674	.18	7	Some cirri low in east.
	1.907	M_2						
	1.927	$M_{1.5}$						
	1.917	W. M.						
Apr. 7	1.958	E_0	V. G.	.862	.671	.26	12	Cloudless.
	1.893	$M_{2.5}$						
	1.909	M_2						
	1.921	$M_{1.5}$						
	1.927	W. M.						
A. M. Apr. 8	1.938	$M_{1.42}$	S.	.876	[2] .671	.29	13	Do.
	1.943	$M_{1.32}$						
	1.929	$M_{1.25}$						
	1.937	W. M.						
Apr. 9	1.877	$M_{2.89}$	S.	.879	[3] .616	.30	25	Do.
	1.935	$M_{2.28}$						
	1.935	W. M.						
Apr. 11	1.927	$M_{1.86}$	S.	.875	[4] .590	.41	25	Do.
	1.936	$M_{1.63}$						
	1.945	$M_{1.45}$						
	1.939	W. M.						
P. M. Apr. 12	1.831	$M_{2.46}$	S.	.872	.474	.40	20	Cirri prevented morning observations. Cumuli over high peaks.
	1.882	$M_{2.06}$						
	1.907	$M_{1.78}$						
	1.886	W. M.						
Apr. 13	1.995	$M_{3.04}$	S.	.870	[5] .386	.41	21	Cirri prevented further observations.
Apr. 18	1.927	$M_{1.62}$	S.	.883	[6] .695	.20	7	Cirri in north and east.
	1.994	$M_{1.50}$						
	1.935	W. M.						
Apr. 19	1.924	$M_{1.40}$	S.	.883	[7] .702	.27	10	Cirri in east and north.
	1.942	$M_{1.31}$						
	1.935	W. M.						
Apr. 22	1.916	$M_{1.66}$	S.	.884	[8] .665	.13	5	Distant cirri in west, north, and east.
	1.921	$M_{1.55}$						
	1.918	W. M.						
Apr. 29	1.941	$M_{1.68}$	S.	.883	[9] .733	.13	50	Small patches of cirrus scattered about sky.
A. M. Apr. 30	1.915	$M_{1.92}$	S.	.888	.585	.19	11	Cirri low in east.
	1.909	$M_{1.74}$						
	1.912	W. M.						
P. M. May 8	1.910	$M_{3.27}$	S.	.885	[10] .577	.18	11	Cirri low in west.
May 9	1.857	$M_{2.54}$	V. G.	.888	.684	.19	11	Cloudless.
	1.867	$M_{2.01}$						
	1.908	$M_{1.70}$						
	1.886	W. M.						
A. M. May 10	1.958	E_0	E.	.875	.725	.16	15	Do.
	1.912	$M_{2.5}$						
	1.934	M_2						
	1.939	$M_{1.5}$						
	1.936	W. M.						
P. M. May 11	1.945	$M_{3.8}$	V. G.	.887	.690	.17	10	Do.
	1.917	$M_{3.74}$						
	1.905	$M_{3.69}$						
	1.922	W. M.						
A. M. May 12	1.934	$M_{1.64}$	S.	.885	[11] .721	.15	11	Do.
	1.931	$M_{1.50}$						
	1.932	W. M.						
P. M. May 19	1.936	$M_{2.34}$	S.	.884	.623	.42	23	Do.
	1.893	$M_{1.94}$						
	1.912	$M_{1.65}$						
	1.918	W. M.						

[1] Air mass 2.20.
[2] Air mass 1.42.
[3] Air mass 2.28.
[4] Air mass 1.86.
[5] Air mass 3.04.
[6] Air mass 1.62.
[7] Air mass 1.40.
[8] Air mass 1.66.
[9] Air mass 1.68.
[10] Air mass 3.27.
[11] Air mass 1.64.

WEATHER OF NORTH AMERICA AND ADJACENT OCEANS.

NORTH ATLANTIC OCEAN.

By F. A. YOUNG.

The average pressure for the month was considerably above the normal at land stations on the west coast of Newfoundland and in eastern Canada, as well as in the Azores, Bermudas, and British Isles; it was slightly lower than usual at St. Johns, Newfoundland, and in the West Indies, while the departures were small on the Atlantic and Gulf coasts of the United States.

The number of days on which fog was observed was apparently somewhat greater than usual over the banks of Newfoundland; fog was also reported frequently over the mid-section of the steamer lanes, but was comparatively rare off the coast of Europe.

With the exception of July, June is ordinarily the quietest month of the year on the North Atlantic, and during the month under discussion the days on which winds of gale force were reported were even less than usual. While a few cyclonic disturbances occurred, they were, as a rule, of limited intensity and extent.

From the 1st to the 4th high pressure with light to moderate winds was the rule over the entire ocean, while fog prevailed over the Grand Banks.

On the 5th and 6th conditions were about the same as far as pressure, wind, and fog were concerned, except that the British S. S. *Hartington*, while in the region between the Azores and the Spanish coast, encountered a northerly gale with barometic readings of over 30 inches. No storm logs from other vessels were received, and craft in the vicinity reported winds with a force of from 4 to 6 at the Greenwich mean noon observations taken on these dates. Report follows:

June 5, moderate gale, light NE. swell. Overcast with heavy rain at times. June 6, moderate gale, high sea, and NE. swell. Overcast with heavy rain. Position: Greenwich mean noon on the 6th, latitude 42° N., longitude 18° W.

From the 7th to the 10th there ensued another comparatively quiet period, with fog over the Grand Banks.

From the 11th to the 13th there was a fairly well-developed area of low pressure central near St. Johns, Newfoundland. This was practically the only disturbance of any consequence during June and was of limited intensity and extent. Later in the month, however, a few storm-logs were received from vessels in widely scattered localities. On the 12th and 13th comparatively heavy weather prevailed over the region between the 35th and 42d parallels and the 47th and 57th meridians. On the former date one vessel in the middle section of the steamer lanes encountered winds of gale force after the time of Greenwich mean noon observation. Storm-logs follow:

American S. S. *Dallas:*

Gale began on the 11th; wind SW. Lowest barometer 29.88 inches at 11 p. m. on the 11th; wind SW., 6, in latitude 41° 29′ N., longitude 50° 42′ W. End on the 12th; wind SW. Highest force of wind, 8; steady from the SW. Barometer rising throughout.

British S. S. *Venturia:*

Gale began on the 12th; wind ESE. Lowest barometer 30.05 inches at 10 p. m. on the 12th; wind S., 7, in latitude 50° 11′ N., longitude 34° 52′ W. End on the 13th; wind SW. Highest force of wind 8, S. by E.; shifts S.-SW.

American S. S. *Independence Hall:*

Gale began on the 12th; wind SW. Lowest barometer 29.97 inches at 6 a. m. on the 12th; wind SW., 7, in latitude 40° 30′ N., longitude 49° 20′ W. End on the 13th; wind SW. Highest force of wind 8, SW.; steady from SW.

American S. S. *Conness Peak:*

Gale began on the 12th; wind SSW. Lowest barometer 29.83 inches at noon on the 12th; wind SSW., 7, in latitude 38° 31′ N., longitude 55° 42′ W. End on the 13th; wind SSW. Highest force of wind 8, SSW.; steady from SSW.

From the 14th to the 16th moderate weather was the rule. On the former date fog was observed in mid-ocean. Conditions had not changed materially by the 17th, except that moderate northwesterly gales were reported at Malin Head, Ireland, and also by the British S. S. *Gloria de Larrinaga*, which on that date was about 250 miles west of the coast of Scotland. Storm-log:

Gale began on the 16th; wind W. Lowest barometer 29.90 inches on the 19th; wind NW., in latitude 55° N., longitude 24° 30′ W. End on the 20th; wind W. Highest force of wind 9; shifts W.-NW.

On the 19th the American S. S. *Dallas* encountered a moderate westerly gale in the same region, although other vessels near by experienced only light to moderate winds. Storm-log:

Gale began on the 18th; wind NW. Lowest barometer 29.90 inches at 1 p. m. on the 19th, wind W., 6, in latitude 58° 09′ N., longitude 17° 01′ W. End on the 19th; wind W. Highest force 8; steady from W. Barometer falling throughout.

From the 20th to the 29th, the usual stagnant atmospheric conditions prevailed over practically the entire ocean, and the American S. S. *Tripp* was the only vessel to render a storm-log during that period, as follows:

From noon to midnight on the 23d moderate southerly gale, near latitude 38° N., longitude 63° W. Highest force of wind 8, S.

A rather unusual case of abnormal refraction was reported from the British S. S. *Cadillac* as follows:

June 26 and 27 abnormal refraction observed. Observation at morning and evening twilight (stars) differing from day (sun) observation by from 12 to 17 miles. No appreciable difference between sea and air temperatures, or barometric changes. Greenwich mean noon position on the 26th; latitude 40° 09′ N., longitude 64° 25′ W.

On the 30th there was apparently a fairly well-developed area of low pressure over the eastern part of the steamer lanes, although not enough observations have been received for an accurate determination of its extent or position. Storm-logs follow:

British S. S. *Bristol City:*

Gale began on the 29th; wind SSW. Lowest barometer 30 inches at 3 a. m. on the 30th; wind W., 8, in latitude 47° 30′ N., longitude 33° W. End on the 30th; wind NW. Highest force of wind 8; shifts W.-NW.

American S. S. *St. Paul:*

Gale began on the 30th; wind SW. Lowest barometer 29.80 inches at midnight on the 30th; wind SW., 8, in latitude 48° 19′ N., longitude 20° 25′ W. End on July 1; wind NW. Highest force of wind 8; shifts SW.-W.-NW.

NORTH PACIFIC OCEAN.

By WILLIS E. HURD.

It is the usual expression that June is a quiet month over the North Atlantic and the North Pacific Oceans. The reports from the North Atlantic indicate few atmospheric disturbances during June, 1922, and those from the North Pacific, except perhaps from the Far East, are almost equally as assertive of quiet conditions. The chief officer of the Norwegian S. S. *Hanna Nielsen*, bound from Tsingtau, China, to Astoria, Oregon, from May 27 to June 13, thus tersely remarked: "Unusual calm sea and weather, except the days with fog, all the way over."

Aside from the generally calm seas and quiet weather the appearance of fog was most frequently noted by shipping. East of the 180th meridian fog occurred during the first six or eight days of the month over the northern routes and sporadically thereafter at least until the 18th. West of the 180th meridian, fully 40 per cent of the observers reported fog during the early half of June, and several reported it practically throughout the remainder of the month.

Pressure changes, except in the typhoon region and thence over the Aleutians and eastward, were moderate. At Honolulu the absolute range of pressure was only 0.25 inch. Here unusually cloudy conditions prevailed, with the lowest percentage of sunshine in 18 years of record. It was also the calmest June on record.

The eastern North Pacific high-pressure area did not assume control of weather conditions until the 10th. Previously a shallow but well-defined low-pressure area had hung off the American coast. After the 16th another shallow depression nosed its way into the high-pressure area from the westward completely severing it from about mid-ocean to British Columbia until about the 19th. Owing to these and other changes, the average pressure over much of this region was below normal.

The Aleutian low-pressure area was especially prominent from the 7th to the 9th and from the 20th to the 24th; and was again assuming energetic indications on the 30th. The circulation over this area was weak, however, and no gales of consequence seem to have occurred.

In Mexican and Central American waters conditions were reported quiet except for a gale to the southward of Salina Cruz on the night of the 3d, due to the oncoming summer conditions peculiar to this locality at the beginning of the rainy season.

In the Far East reports received up to the 17th of the month show five cyclones passing near or over Japan. Of these two were of continental origin, giving moderate to strong gales; two were semi-tropical depressions; and the fifth, a storm which persisted from the 8th to the 11th of the month, was a typhoon of considerable intensity. The typhoon originated to the northwestward of Luzon, moved northeastward, and disappeared at sea to the eastward of Japan. The Yellow Sea depression of the 15th–17th seems to have been instrumental in breaking the rather serious drouth which had been existing over western Japan. Two other storms of this region, which originated during the last days of May disappeared on the 1st or 2d of June near the 150th meridian, giving reported gales of force 7.

Of the storms of continental origin enumerated in the foregoing, that which passed out to sea to the northward of Formosa on the 6th, gave moderate to whole gales, especially on the 7th and 8th. The American steamer *Nanking*, Capt. T. H. Dobson, Observer E. J. Anderson, reports the following:

June 8th, 2 a. m.: Lat. 34° 50′ N., long. 142° 30′ E., fresh ENE. wind, overcast, heavy wind and rain squalls, horizon hazy. Wind increased steadily, so by noon it was blowing force 9. Raining very hard, horizon very hazy. Wind hauling around to NE. 4 p. m.: Lat. 34° 50′ N., long. 144° E.; barometer reading 29.23; wind north, force 9; raining hard, with very heavy wind and rain squalls. 12 midnight: Lat. 34° 25′ N., long. 145° 48′ E.; wind NW., 7; bar. 29.39; sea rough; partly cloudy; passing heavy wind and rain squalls. [correction of −0.19 applied to barometer readings.]

Another depression, but of little known intensity appeared over the Japanese Archipelago about the 24th. On the 26th and 27th gales of force 7 to 9 were reported by two steamships from between latitudes 40° and 45° N., longitudes 160° and 165° E., with pressure as low as 29.37 inches. The relation between this depression and the one noted to the westward on the 24th is obscure.

The American S. S. *Victoria*, Capt. C. S. Davis, Observer M. C. Reaber, Seattle to Nome, while near 57° N., 167° W., on the 11th reported occasional snow squalls. On the 12th the observer states: "Ship in heavy floe ice at 1 a. m., lat. 62° 02′ N., long. 167° 59′ W. No ice north of 62° 30′ N."

THE MANILA TYPHOON OF MAY 23, 1922.

By Rev. JOSE CORONAS, S. J.

[Weather Bureau, Manila, P. I.]

The first typhoon of the season traversed the central part of the Philippines in a northwesterly direction on May 20 to 23, the center having passed practically over Manila in the morning of the 23d. Fortunately for the city, however, the typhoon was here very abnormal, as the winds were not very strong, even the barometer was rising rapidly after the passing of the vortex. Hence Manila missed the worst of the storm, and although the barometric minimum in the present case, 742.3 mm. (29.22 inches), was somewhat lower than in the two previous typhoons of August 31, 1920, and July 4, 1921, yet the damage done was much smaller, the maximum velocity of the wind, even in a few isolated gusts, having not been higher than 60 miles per hour.

The center, as just stated, passed practically over Manila, though a little to the west, as was shown by winds veering very rapidly (less than two hours) from NNW. and N. to the E. and S. and by the relative calm, which was clearly observed for about 23 minutes, from 8:01 to 8:24 a. m.

Our weather map for 2 p. m. of the 19th showed the typhoon over the Pacific about 200 miles to the east of Mindanao. The center passed near Surigao to the north between 5 and 6 p. m. of the 20th, and at 6 a. m. of the 21st it was situated over the northernmost part of Cebu Island near 124° longitude E. and 11° latitude N., moving approximately to NW. by W. The typhoon was headed for Mindoro, but a slight inclination of the track to the north caused it to go from Romblon to Marinduque and from Marinduque to Manila. After striking Manila, however, it took again the former direction to NW. by W., thus entering the China Sea near and to the south of Iba.

The following are the most important barometric minima recorded in the Philippines in this typhoon:

Place.	Date.	Hour.	Pressure.	
			Mm.	*Inches.*
Surigao	20	5:45 p. m.	744.95	29.33
Maasin, Leyte	20	10:50 p. m.	746.90	29.41
Romblon	22	9–10 a. m.	746.90	29.41
Boac, Marinduque	22	8:30 p. m.	741.90	29.21
Lucena, Tayabas	23	1:15 a. m.	747.70	29.44
Sta. Cruz, Laguna	23	4:50 a. m.	746.10	29.37
Manila	23	8:20 a. m.	742.30	29.22
Iba	23	3:00 p. m.	747.29	29.42

While the rate of progress of the typhoon between Surigao and Maasin was 8 or 9 miles per hour, it decreased later to such an extent that from Romblon to Boac the storm moved at the rate of only 5.6 miles per hour. When nearing Manila it increased again to about 8 miles per hour and from Manila to Iba the rate of progress was even greater than 10 miles per hour.

According to the observations at hand it would seem that the typhoon filled up on the 26th in the China Sea off Hainan.

Besides this Manila typhoon there was only one other shown by our weather maps during this month in the whole Far East. It appeared south of Guam on May 2, not far from 145° longitude E. and 10° latitude N. and moved northwestward between Guam and Yap.

NOTES ON WEATHER IN OTHER PARTS OF THE WORLD.

Canada.—OTTAWA, ONT., June 23.—A severe windstorm sweeping east from the Kenora district to-day put all telegraph wires out of commission west of Fort Williams and blew a box car from the track at Lydiatt, 40 miles east of Winnepeg. Meager reports received here indicated that lightning and heavy hail caused great damage.—*Washington Evening Star, June 23, 1922.*

British Isles.—The rainfall of the month of June was generally below the average, considerable areas in the southern half of Ireland and the center of England receiving less than half the average. Areas with excess rainfall occurred mainly in the Western Highlands of Scotland. * * *

In London, Camden Square, the mean temperature was 60.7° F., or 0.5° F. above the average; the duration of rainfall, 15.9 hours; and the evaporation, 3.36 inch.[1]

Rumania.—BUCHAREST, June 23.—Twenty persons lost their lives as a result of a cloud-burst and windstorm yesterday in the Bistritz district of Transylvania, according to dispatches received here. Hundreds of houses were destroyed and thousands of persons are homeless.—*New York Times, June 24, 1922.*

Bulgaria.—SOFIA, June 21.—Ten thousand persons have been rendered homeless by devastating floods which inundated the suburban districts of Sofia after torrential rains. No loss of life has been reported. There was much damage to livestock.—*New York Times, June 22, 1922.*

Algeria.—On the 1st severe hailstorms, which destroyed the crops in certain parts, were reported from Algeria.[1]

India.—The amount and distribution of Indian rainfall during the month was satisfactory except in Katiawar, southern Hyderabad and southern Madras, where it was deficient. The monsoon was normal; and there were no storms in the Bay of Bengal.[1]

Japan.—A message received on the 24th stated that southwest Japan was suffering from a drought such as had been unknown for forty years. Rice cultivation was being abandoned in many districts.[1]

New Zealand.—A very severe gale occurred over northern New Zealand on the night of May 31 and continued until June 3.[1]

Argentina.—BUENOS AIRES, June 23.—The present winter in the southern part of Argentina is one of the severest in history. There has been continued cold weather for more than a month, with heavy snowfall. The snow on the ground in some of the cities has reached a maximum depth of four feet. Considerable damage to the crops and cattle is reported from some points.—*New York Times, June 24, 1922.*

Brazil.—The special message from Brazil states that in the northern region the rainfall of the month was on the average 90 mm. above normal, several stations having over 200 mm. excess. Severe floods occurred in the Amazon basin and in Parahyba State. Rainfall was also above average in the central and southern districts, and the cane and cotton crops have suffered generally. Temperature was on the whole in excess of normal. Violent storms occurred at the end of the month in the extreme south of the country.[1]

San Salvador.—SAN SALVADOR, June 14.—Three hundred persons are known to have been drowned and many are missing, following an abnormal rise in the Acelhuate and Arenal Rivers, which overflowed their banks and joined together in one stream, inundating the Candelaria district of this city.—*Washington Post, June 15, 1922.*

[1] *The Meteorological Magazine*, July, 1922, pp. 175-176.

[1] *The Meteorological Magazine*, July, 1922, pp. 175-176.

DETAILS OF THE WEATHER IN THE UNITED STATES.

GENERAL CONDITIONS.

By A. J. HENRY.

Among the larger features of June weather must be recognized the following: (1) High pressure over the western margin of the Atlantic, also on the Pacific off Washington and Oregon; (2) the northerly track followed by anticyclones and their dissolution in the Lake region and the western slope of the Appalachians; (3) excessive rains in New York and New England and drought in Illinois, Indiana, Iowa, Missouri, Kansas, Nebraska, and Oklahoma. To what extent the high pressure over both oceans adjacent to the Continent was responsible for the character of the weather over the interior, it is, of course, impracticable to say. The usual details follow.

CYCLONES AND ANTICYCLONES.

By W. P. DAY, Observer.

Several of the migratory cyclones charted are shown as originating over the Rocky Mountain and Plateau regions and on the eastern slope, but this feature is more apparent than real. During the warmer months there is normally a difference of half an inch in pressure between the Pacific anticyclone and the continental low-pressure area immediately to the east. Small pressure waves apparently move into this area between the two systems without greatly disturbing the visible form of the isobaric contours. They become lost in the larger circulation. In the case of falling pressure the wave moves eastward and northward appearing as a bud or offshoot from the continental low-pressure area. In charting the centers of minimum pressure the point where the offshoot establishes itself as a separate circulation is taken as the origin of a particular cyclone. However, during June the formation of a storm over the Rocky Mountain region or on the eastern slope was preceded from one to two days by falling pressure on the Pacific coast.

Tables showing the number of cyclones and anticyclones by types follow:

CYCLONES.	Alberta.	North Pacific.	South Pacific.	Northern Rocky Mountain.	Colorado.	Texas.	East Gulf	South Atlantic.	Central.	Total.
June, 1922	4.0	......	......	3.0	3.0	......	......	......	4.0	14.0
Average number, 1892-1912, inclusive	3.3	0.8	0.4	0.7	1.2	0.4	0.2	0.3	1.1	8.4

ANTICYCLONES.	North Pacific.	South Pacific.	Alberta.	Plateau and Rocky Mountain region.	Hudson Bay.	Total.
June, 1922	4.0	......	2.0	......	2.0	8.0
Average number, 1892-1912, inclusive	1.7	0.6	1.9	0.9	0.5	5.6

FREE-AIR CONDITIONS.

By L. T. SAMUELS, Meteorologist.

Free-air temperature departures for the month were, in general, positive, there being no negative departures greater than 1.0° C. (See Table 1.) Consistent with the mean surface temperatures as compared with their normals (see Chart III), the greater excess was observed in the interior of the country, Drexel reporting the largest departures followed by Broken Arrow and Groesbeck, respectively. The departures at each of these stations increased, generally, with altitude. The other three stations reported means varying only slightly from their averages from the surface to the highest levels.

Relative humidities were below the average at Broken Arrow, Drexel, and Ellendale, but slightly above at the other three stations. It is interesting to note that the monthly precipitation at these stations was either above or below normal as was the relative humidity above or below its average, with the exception of Royal Center, where the departures of the latter were slightly positive, yet the monthly precipitation was appreciably below the normal amount.

The vapor pressure, in general, followed the temperature as regards departures from the average. Irregularities in this respect were very probably due largely to the short period of record from which the averages have been computed.

Table 2 gives the free-air wind resultants and examination will show that as a rule where temperature departures are above the average the resultant winds have a more southerly component or at least a greater resultant velocity than normally.

As is to be expected winds become much lighter at this season of the year. Only a few observations during the month showed winds of 30 m. p. s. or more, all of these being single-theodolite pilot-balloon observations. These are given in the following table:

Stations.	Date.	Direction.	Velocity.	Altitude.
			M. p. s.	*Meters.*
Ithaca, N. Y	12	wnw	32	1,100
Lansing, Mich	10	w	38	4,000
Camp Lewis, Wash	16	w	35	6,100
Mather Field, Calif	19	sw	39	10,300
Do	21	sw	34	5,900
Mitchel Field, N. Y	12	wnw	33	3,200
Royal Center, Ind	12	wnw	32	3,100

The high winds observed at Lansing on the 10th and at Ithaca, Mitchel Field and Royal Center on the 12th were an accompaniment of the cyclonic depression which caused numerous local disturbances and squalls, the most severe of which was the one occurring in the vicinity of New York City on the 11th.

Easterly winds at high altitudes become more frequent at this season and especially at the southern stations, where such winds were observed on about two-thirds of the total number of days in the month. No marked connection can always be associated with these winds and the surface-pressure distribution, but rather they seem to be the result of the transition from winter to summer conditions in the Northern Hemisphere. Such winds prevailed generally over the northern portion of the country from the 1st to the 4th and in the southern and southeastern part on the 5th and 6th. This seems significant in view of the fact that a strong, high-pressure area central over Montana on May 30, had gradually decreased in strength so that by June 4, six days later, it had moved only as far as the Mississippi Valley and had flattened so much that it lost its individuality and had become part of the greater high-pressure area centered over the Atlantic Ocean.

Similar winds were observed over the southern and eastern sections from the 20th to the 25th. The latitudinal surface-temperature gradients during this period were extremely small and therefore easterly winds aloft might be expected.

Conditions were favorable for reaching high altitudes with pilot balloons at Groesbeck, Tex. on the 14th and at Key West, Fla. on the 22d. Heights of 15,000 m. and 17,000 m. were reached at Groesbeck and Key West, respectively. The observation at Groesbeck was made with two theodolites and is therefore more trustworthy and of special interest since two-theodolite observations reaching this altitude are not numerous. Winds were light from the surface to the highest levels, the velocities never exceeding 9 m. p. s. The direction was southerly from the surface to 10,500 m., changing sharply to northerly and continuing to the highest level. The velocities at Key West were very light from the surface to 13,000 m. when they increased from about 3 m. p. s. to about 10 m. p. s. at 14,000 m. and 16 m. p. s. at 17,000 m. The direction was easterly from the surface to nearly 3,000 m., then changing to westerly through north and remaining so to 13,000 m., above which altitude it remained mostly north.

TABLE 1.—*Free air temperatures, relative humidities, and vapor pressures during June, 1922.*

TEMPERATURE (°C.).

Altitude m. s. l. (*m.*)	Broken Arrow, Okla. (233*m.*)		Drexel, Nebr. (396*m.*)		Due West, S. C. (217*m.*)		Ellendale, N. Dak. (444*m.*)		Groesbeck, Tex. (141*m.*)		Royal Center, Ind. (225*m.*)	
	Mean.	Departure from average.	Mean.	Departure from average.	Mean.	Departure from average.	Mean.	Departure from average.	Mean.	Departure from average.	Mean.	Departure from average.
Surface	25.4	+0.8	22.8	+1.1	25.9	−0.3	18.9	−0.9	25.2	−0.3	23.9	+0.3
250	25.3	+0.8	......	......	25.6	−0.2	......	......	24.7	+0.1	23.6	+0.3
500	23.8	+1.4	21.9	+0.9	23.2	+0.2	18.8	−0.7	23.6	+0.8	20.7	+0.1
750	22.2	+1.5	20.6	+1.2	21.7	+0.4	18.1	+0.2	22.3	+1.0	18.7	+0.1
1,000	20.6	+1.3	19.2	+1.2	20.5	+0.5	16.9	+0.2	21.1	+1.2	17.4	+0.3
1,250	18.9	+1.1	17.6	+1.0	19.0	+0.4	15.6	0.0	19.8	+1.2	16.1	+0.5
1,500	16.9	+0.8	16.4	+1.1	17.3	+0.3	14.5	+0.2	18.6	+1.5	14.6	+0.5
2,000	14.1	+1.1	14.1	+1.6	14.2	+0.3	11.7	+0.3	16.2	+1.7	11.5	+0.2
2,500	11.5	+1.1	11.0	+1.7	10.9	+0.1	8.8	+0.3	13.5	+1.7	8.2	−0.2
3,000	9.2	+1.7	8.6	+2.4	7.5	−0.1	5.7	+0.1	11.1	+1.8	5.7	0.0
3,500	6.6	+1.9	5.2	+2.4	3.7	−0.5	2.4	−0.3	8.8	+2.1	3.0	−0.1
4,000	3.7	+1.9	2.4	+2.9	0.3	−0.6	−0.2	−0.1	6.1	+1.9	0.8	−0.1
4,500	1.1	+1.9	......	......	−1.2	−0.2	−2.9	+0.4	3.5	+1.7	......	......

RELATIVE HUMIDITY (%).

Altitude m. s. l. (*m.*)	Broken Arrow Mean.	Departure from average.	Drexel Mean.	Departure from average.	Due West Mean.	Departure from average.	Ellendale Mean.	Departure from average.	Groesbeck Mean.	Departure from average.	Royal Center Mean.	Departure from average.
Surface	73	0	64	−4	66	+3	73	+1	79	+4	59	−2
250	73	0	......	......	66	+2	......	......	78	+3	60	−1
500	71	−2	63	−4	67	0	71	0	77	+2	63	+1
750	70	−3	59	−6	66	−1	64	−5	75	+1	65	+1
1,000	70	−3	60	−5	66	−1	61	−6	71	−1	66	+1
1,250	70	−3	60	−4	66	0	60	−5	68	−2	67	+1
1,500	68	−4	57	−5	66	0	57	−6	63	−4	68	+2
2,000	59	−9	53	−6	66	+1	54	−7	58	−3	65	+2
2,500	48	−10	52	−6	67	+3	53	−6	59	+2	60	+6
3,000	40	−13	49	−8	67	+4	53	−2	55	+5	55	+7
3,600	40	−12	57	0	68	+4	54	+1	52	+5	46	+5
4,000	39	−9	39	−18	56	+4	50	0	46	+1	26	0
4,500	29	−9	......	......	32	+4	50	−8	47	−2	......	......

VAPOR PRESSURE (*mb.*)

Altitude m. s. l. (*m.*)	Broken Arrow Mean.	Departure from average.	Drexel Mean.	Departure from average.	Due West Mean.	Departure from average.	Ellendale Mean.	Departure from average.	Groesbeck Mean.	Departure from average.	Royal Center Mean.	Departure from average.
Surface	23.51	+0.92	17.47	−0.24	21.68	+0.71	15.89	−1.08	25.27	+0.99	17.39	−0.60
250	23.35	+0.97	......	......	21.36	+0.74	......	......	24.24	+0.98	17.24	−0.51
500	20.92	+1.08	16.34	−0.28	19.02	+0.68	15.37	−1.05	22.12	+1.05	15.47	−0.03
750	18.78	+0.94	14.24	−0.30	17.28	+0.48	12.98	−1.31	19.98	+0.94	14.31	+0.13
1,000	17.14	+0.90	13.15	−0.13	15.92	+0.71	11.55	−1.23	17.51	+0.63	13.27	+0.16
1,250	15.49	+0.71	12.02	+0.02	14.51	+0.63	10.46	−0.95	15.39	+0.38	12.39	+0.21
1,500	13.67	+0.45	10.56	−0.05	12.98	+0.43	9.34	−0.87	13.30	+0.15	11.29	+0.41
2,000	9.76	−0.42	8.32	−0.07	10.69	+0.53	7.40	−0.89	10.59	+0.34	8.45	+0.22
2,500	6.60	−0.51	6.51	−0.24	8.82	+0.67	6.20	−0.57	9.20	+0.99	5.70	+0.23
3,000	4.82	−0.36	5.28	−0.24	7.16	+0.69	5.18	−0.05	7.46	+1.16	3.93	+0.23
3,500	4.18	+0.01	5.21	+0.73	5.68	+0.69	4.25	0.00	6.20	+1.10	2.18	+0.06
4,000	3.63	+0.30	3.26	−0.40	3.63	+0.69	3.62	+0.08	5.08	+0.77	0.18	−0.14
4,500	2.71	+0.30	......	......	1.82	+0.69	3.22	−0.06	4.83	+0.92	......	......

TABLE 2.—*Free-air resultant winds (m. p. s.) during June, 1922.*

Altitude, m. s. l. (m.)	Broken Arrow, Okla. (233m.)				Drexel, Nebr. (396m.)				Due west, S. C. (217m.)				Ellendale, N. Dak. (444m.)				Groesbeck, Tex. (141m.)				Royal Center, Ind. (225m.)			
	Mean.		Average.		Mean.		Average.		Mean.		Average.		Mean.		Average.		Mean.		Average.		Mean.		Average.	
	Dir.	Vel.	Dir.	Vel.	Dir.	Vel.	Dir.	Vel.	Dir.	Vel.	Dir.	Vel.	Dir.	Vel.	Dir.	Vel.	Dir.	Vel.	Dir.	Vel.	Dir.	Vel.	Dir.	Vel.
Surface	S. 19° W.	3.9	S. 4° W.	3.6	S. 2° E.	3.0	S. 8° W.	1.5	S. 85° W.	1.9	N. 24° W.	0.7	N. 65° W.	2.0	S. 45° E.	0.1	S. 7° W.	1.7	S. 15° E.	2.7	N. 81° W.	1.4	S. 48° W.	0.8
250	S. 19° W.	3.9	S. 4° W.	3.7					S. 85° W.	2.0	N. 34° W.	0.7					S. 4° W.	2.4	S. 15° E.	3.2	N. 83° W.	1.5	S. 47° W.	0.8
500	S. 23° W.	5.5	S. 12° W.	4.9	S. 2° E.	3.9	S. 7° W.	2.0	S. 85° W.	2.8	N. 58° W.	1.1	N. 71° W.	2.2	S. 13° E.	0.3	S. 11° W.	3.8	S. 5° E.	4.3	S. 79° W.	2.5	S. 42° W.	1.8
750	S. 23° W.	6.4	S. 15° W.	5.7	S. 8° W.	5.8	S. 19° W.	3.0	S. 85° W.	3.1	N. 80° W.	1.7	N. 85° W.	2.3	S. 8° W.	0.9	S. 9° W.	4.4	S. 3° E.	4.6	S. 84° W.	3.4	S. 51° W.	2.3
1,000	S. 21° W.	6.3	S. 20° W.	5.9	S. 19° W.	6.6	S. 34° W.	3.6	N. 81° W.	3.1	N. 66° W.	1.3	N. 87° W	2.6	S 20° W.	1.3	S. 3° W.	4.8	S.	4.9	N. 84° W.	4.6	S. 71° W.	2.9
1,250	S. 21° W.	6.4	S. 23° W.	6.2	S. 24° W.	6.7	S. 45° W.	4.0	N. 71° W.	3.4	N. 58° W.	1.4	N. 89° W.	3.1	S. 50° W.	2.0	S.	5.4	S. 3° W.	5.5	N. 84° W.	5.1	S. 79° W.	3.3
1,500	S. 24° W.	6.5	S. 27° W.	6.3	S. 34° W.	6.6	S. 57° W.	4.5	N. 71° W.	3.4	N. 69° W.	1.7	S. 86° W.	3.4	S. 51° W.	2.3	S. 1° W.	5.6	S. 2° W.	4.9	N. 78° W.	6.2	N. 86° W.	3.8
2,000	S. 33° W.	6.0	S. 32° W.	6.5	S. 46° W.	6.7	S. 62° W.	5.8	N. 79° W.	4.9	N. 81° W.	3.0	W.	5.0	S. 63° W.	3.5	S. 1° E.	6.1	S. 2° W.	4.7	N. 83° W.	11.1	S. 89° W.	5.9
2,500	S. 31° W.	5.4	S. 29° W.	6.5	S. 52° W.	9.3	S. 72° W.	6.7	N. 83° W.	6.2	N. 81° W.	4.0	S. 87° W.	8.4	S. 72° W.	5.3	S. 7° W.	6.4	S. 9° W.	4.5	N. 82° W.	13.1	S. 88° W.	8.1
3,000	S. 35° W.	5.2	S. 19° W.	6.7	S. 53° W.	11.6	S. 78° W.	8.5	S. 88° W.	7.0	N. 86° W.	5.4	S. 80° W.	12.2	S. 78° W.	7.2	S. 4° W.	7.2	S. 15° W.	5.0	N. 79° W.	16.0	W.	10.9
3,500	S. 49° W.	5.2	S. 22° W.	7.9	S. 61° W.	11.6	S. 80° W.	9.2	S. 73° W.	7.3	S. 72° W.	5.8	S. 83° W.	12.5	S. 81° W.	8.4	S. 4° W.	7.4	S. 11° W.	6.4	N. 78° W.	15.9	N. 89° W.	12.8
4,000	S. 64° W.	6.1	S. 37° W.	7.0	N. 79° W.	13.7	N. 81° W.	8.7	S. 76° W.	7.6	S. 73° W.	8.7	N. 82° W.	15.6	N. 85° W.	10.1	S. 12° E.	10.4	S. 4° E.	7.2	N. 70° W.	18.8	S. 87° W.	15.6
4,500	N. 35° W.	4.9							N. 56° W.	10.4			N. 82° W.	13.3	N. 70° W.	14.0	S. 22° E.	15.0	S. 29° E.	12.2				
5,000									N. 55° W.	9.8			N. 82° W.	13.7	N. 73° W.	17.5								

THE WEATHER ELEMENTS.

By P. C. DAY, Climatologist and Chief of Division.

PRESSURE AND WINDS.

As is usual in June, pressure diminished from the May values over the northeastern districts and from the Rocky Mountains westward, the decreases over the far Northwest being much greater than usual. In the central and northern interior districts where the pressure is usually distinctly less in June than in May, there was a rise of considerable importance, while in the southern districts from Texas and Oklahoma eastward, where the normal pressure in June is only slightly higher than in May, the increases during June were quite marked. As a result the pressure gradients for the different portions of the country were unusually small and the flattened system of isobars, common to the summer season, was more pronounced than usual.

While the cyclones and anticyclones formed in somewhat more rapid succession than usual, they were mainly of small dimensions and pursued rather indefinite courses.

The cyclones usually reached their greatest development over the more eastern districts, with a resultant excess of rainfall in those regions. On the other hand, the anticyclones moving southward from the Canadian Northwest attained their maximum intensity over the central valleys and Lake region, with accompanying dry weather in those localities.

For the month as a whole the atmospheric pressure was below normal over the northeastern districts and in parts of the far Northwest. In other districts the pressure was above normal and to a considerable degree in the Rocky Mountain and adjacent regions.

While the barometric gradients were weak the main slope was toward the north over the districts from the Rocky Mountains eastward, and the atmospheric circulation responded accordingly and southerly winds were general over all that region.

From the Rocky Mountains westward to the Pacific, there was some movement toward the low-pressure area over the far Southwest, but in most districts there was the usual diversity of directions, due mainly to varying topography.

No extensive areas had high winds on the same dates save about the 11th and 12th, when thunderstorms prevailed over much of the country from the Great Lakes and Ohio Valley eastward to the Atlantic coast. In some of the more eastern districts severe thunderstorms occurred on the afternoon of the 11th, attended by high winds, heavy rains, considerable loss of life, and much damage to property. A more detailed account of these storms will be found at the end of this section.

TEMPERATURE.

No unusual heat or cold occurred during the month over extensive areas or periods, and the ranges from day to day were usually small.

The first week of the month was moderately cool over the interior valleys and southern States, and generally warm from the Ohio Valley eastward, along the northern border, and over most of the Plateau and Pacific Coast States, though it was cooler than normal in portions of California.

Conditions were partially reversed during the second week when there was a decided rise in temperature over all interior and eastern districts, and a general lowering along the northern border from the Great Lakes westward. Cool weather prevailed in the Great Valley of California, and it continued cool in the West Gulf section.

The third week of the month continued warm over the central valleys and Northwest, but a change to decidedly cooler overspread the Northeastern States, and temperatures below normal continued in western Texas, and extended into New Mexico and eastern Arizona.

The final week of the month continued warmer than normal over most districts from the Mississippi and Missouri Rivers westward, the warmth extending into the Southwest where temperatures below normal had persisted during much of the preceding portion of the month. This week continued warm over the Southern States, but like the preceding week it remained cooler than normal over the Northeast, the coolness extending into the Ohio Valley and Lake region.

For the month as a whole temperature averaged above normal over nearly all portions of the country, the only exceptions being small areas in central and western Texas and the adjoining portion of New Mexico, and locally in the northern portions of New York and Vermont.

At a few points the month as a whole was warmer than any preceding June, notably in western Montana, northern Idaho, and eastern Washington. In portions of the last-named State, June, 1922, is the first month since November, 1921, with average temperature above the normal.

No particular period of the month had notably high temperatures over large areas, but about the 14th to 15th

the maxima for the month were recorded in most of the Ohio Valley and cotton-region States; about the 19th to 21st over the far Southwest; and from the 20th to 24th over the northern sections from the Rocky Mountains eastward.

The lowest temperatures were observed from the 1st to 3d over nearly all portions of the region from the Plateau to the Mississippi Valley; on the 13th to 14th over the North Atlantic States; and about the 23d to 26th from the Great Lakes to the South Atlantic States.

Temperatures below freezing were observed at exposed points in all the Mountain States of the West, the lowest reported, 12°, occurring at a point in Colorado. Temperatures of 32° or only slightly higher occurred along the northern border extending southward as far as Nebraska and Pennsylvania.

Frosts were observed in Colorado and New Mexico on the 1st, but without material damage, and on the 26th they were severe in northern Michigan, causing much damage to garden truck.

PRECIPITATION.

The rainfall during June, as is usual for a summer month, was mainly the result of thunderstorm activity, and exhibited to an unusual extent the variations in amounts received at near-by stations when thunderstorms prevail.

In the main, precipitation was frequent and usually heavy over most eastern districts, in fact portions of New York and New England had more rain than ever previously recorded in June. On the other hand, the month was distinctly dry in the great central valleys and portions of the far Northwest. In portions of Illinois, Indiana, Iowa, and locally in adjacent States, the total fall for the month was less than 1 inch, in some instances less than half an inch, while at Chicago, Ill., it was but one-tenth of an inch, the least recorded in June for over 50 years, and similar conditions existed at other points in the Middle West. Also in the far Northwest precipitation was in some cases the least of record for June. In fact, save over most of the Atlantic Coast States, and in portions of Texas, the upper Lake region, western Montana, and a few small areas in Arizona and Nevada, June was a distinctly dry month, particularly in the middle Mississippi Valley and central Plains where the deficiencies by States averaged from 1 to nearly 3 inches. Due to the very general and copious rains of the preceding months, however, the soil had been well saturated with moisture, so that no serious drought existed over any extensive area at the close of the month.

SNOWFALL.

In the high Sierra of California snow fell from the 9th to 11th, amounting to as much as 6 inches locally. In other mountain districts of the West snow was reported from a few points only.

The stored snow in the mountain sections furnishing the summer supply of water for irrigation and other purposes in the far West, continued to melt slowly due to continued cool weather up to the middle of the month, after which time melting was more rapid.

At Reno, Nev., the observer reports that more snow was visible in the surrounding mountains at the end of the month than had been observed before in the memory of the oldest inhabitants. In California, the melting snow increased the discharge of Kings River to such a degree that the surplus water overflowed into the dry bed of Lake Tulare, previously plowed and sowed to grain, which was nearly ready for harvest, causing a loss estimated to exceed half a million dollars.

RELATIVE HUMIDITY.

The moisture in the atmosphere as disclosed by the average relative humidity, was in excess of the normal for June over all Atlantic and Gulf Coast States, although the amount of such excess was distinctly less than would be expected from the number of rainy days, marked lack of sunshine, and the generally wet condition of the soil, and other objects.

In the central valleys, where there were long periods without rain, the relative humidity was mainly less than normal, and here too the amount of the deficiency was much less than would be expected considering the marked lack of rain and dry condition of the surface soil.

In the far Northwest and adjoining portions of the Mountain and Plateau regions the relative humidity was less than normal, the deficiencies being as a rule greater than in the central valleys. In other districts the humidity conditions were not materially different from normal.

SEVERE STORMS OF JUNE 11.

A number of severe storms, with violent winds, heavy rains, and sometimes heavy hail, visited large portions of the middle Ohio Valley and the Middle and North Atlantic States on Sunday, the 11th.

On the morning of the 11th, at the hour of regular observation, there was a low-pressure center of unusual energy for the warm season located to north of the upper St. Lawrence Valley, the sea-level pressure at Montreal and at White River being 29.38 inches. By the morning of the 12th the low-pressure area was centered over the western portion of the Gulf of St. Lawrence, readings as low as 29.16 inches being reported from Father Point and Quebec. The high temperatures which had prevailed on the 11th from New York southward to Maryland and southwestward to Ohio and southern Michigan had given way to considerably cooler weather, several places reporting 24-hour drops in temperature of from 10° to 16°.

In the Ohio Valley, while rather high winds occurred practically everywhere, the violent storms seem to have affected mainly some small, scattered areas in three different States. Loss of life occurred in each of these three States. In central Ohio, late in the afternoon, a violent wind struck the region of Buckeye Lake, near Newark. The collapse of several buildings here suggests that a tornado may have occurred, but no evidence of whirling winds or of a funnel cloud is at hand. In the vicinity of Parkersburg, W. Va., the storm was at its height about 7 p. m., 75th meridian time. Some distance to the southwestward, about four hours later, north-central Kentucky was visited. Owen and Henry Counties suffered particularly, but there was considerable damage within the city of Lexington, to southeastward of these counties.

A number of hours earlier, chiefly between midnight and 8 a. m., western and central New York experienced severe storms, the heavy rainfall being here the marked feature. There was, however, considerable wind damage in several counties. A district lying about midway between a line joining Buffalo and Rochester and the Pennsylvania border was visited by unusually high winds. At Delevan, Cattaraugus County, the reports of devastation by the wind during the early morning hours suggest a tornado, but the evidence is not conclusive. At Cort-

land, about 7 a. m., there was great damage by a brief, violent wind, which was probably not a tornado. At that place, and at Syracuse, Oneida, and Salamanca, the rapid rise in small streams due to the heavy rains led to vast damage, chiefly during the forenoon hours.

In the afternoon of the day damage by wind, rain, or occasionally by hail was experienced from northern New Hampshire southward in practically every one of the coast States to Virginia, the time being earliest, as a rule, to northward and northeastward. In Berlin, N. H., the hour of wind damage was 4 p. m. For the New England States, as a whole, the greatest damage seems to have been experienced in a belt crossing in an east-southeastward direction from northwestern Massachusetts and extreme southern Vermont to the Cape Cod district, and here the greatest rainfalls in New England were generally recorded. Considerable wind harm was reported from Pittsfield, Worcester, and from a few miles north of Boston to the vicinity of Brockton; but the greatest wind damage in the State was apparently in Weymouth, Quincy, and vicinity. The places of chief hail damage, however, were well to northward of the places of most wind damage, the hail being felt most in Everett, Malden, and Melrose. The height of the storm, in and near Boston, was between 3 and 4 p. m.

In New York City and vicinity the storm damage was chiefly between 5:30 and 6 p. m. Here the loss of life, and probably of property also, was greatest. While a considerable number of deaths occurred as a result of the storm in various ways and in various localities, yet the large majority came from the effects of a brief, violent thundersquall, that came very suddenly to part of the Bronx section and to the waters of Long Island Sound to southeastward. A Ferris wheel, in operation near the shore, was blown off its bearings and partly demolished, some of the wreckage falling into the water; 7 deaths resulted from this accident. About 50 were drowned by the upsetting of small craft in the squall-swept area.

At Washington, D. C., the violent winds and thunderstorm came about 8 p. m. Many trees were uprooted or broken off, and some persons were injured by accidents due to the wind.

About 10:30 p. m., Sullivan County, in northeastern Pennsylvania, was visited by a small tornado, which traveled about 8 miles southeastward, resulting in one death and much property loss.

Later information indicates that two small tornadoes did occur in New York State, but not at places mentioned above. The first was at Prattsburg, Steuben County, about 6 p. m. on the 10th. The second was in Greene and Columbia counties, about 4 p. m. on the 11th; this storm traveled 20 miles, crossing the Hudson River north of Athens. These storms damaged farm property but caused no deaths.

These storms are mentioned in the table following this section.

SEVERE LOCAL STORMS.

[The table herewith contains such data as have been received concerning severe local storms that occurred during the month. A more complete statement will appear in the annual report of the chief of bureau.]

Place.	Date.	Time.	Width of path (yards).	Loss of life.	Value of property destroyed.	Character of storm.	Remarks.	Authority.
Dublin, Ga	1					Wind	Considerable damage to property, especially to telephone and telegraph lines and shade trees.	Official, U. S. Weather Bureau.
Mexia, Tex. (near)	2	P. m.				do	About 50 derricks demolished and tents and oil shacks blown down.	Dallas Morning News (Tex.).
Scranton, Pa	3					Rain	Streets badly washed, sewers blocked, street car traffic interrupted.	Official, U. S. Weather Bureau.
Lansing, Mich., and vicinity	5	P. m.				Wind, rain, and hail.	Hydroelectric plant incapacitated and other minor damage done.	State Journal (Lansing, Mich.).
Missoula, Mont	5	P. m.				do	General damage done. Loss estimated at thousands of dollars.	Helena Independent (Mont.).
Dayville, Oreg	6	P. m.	6,000			Electrical and hail.	Considerable damage to crops and garden truck, roofs, and trees. Small live stock killed.	Official, U. S. Weather Bureau.
Windsor, N. Y	6	P. m.				Cloudburst	Heavy damage to crops and railroad tracks	The Press (Binghamton, N. Y.).
Middle Tennessee	6			4		Electrical	Some stock killed	Official, U. S. Weather Bureau.
Pulaski and McMinnville, Tenn. (near).	6					Electrical and rain.	No damage reported	Do.
Put-in Bay, Ohio, and vicinity.	9	P. m.				Wind	Damage to buildings, wires, and trees	Star-Journal (Sandusky, Ohio).
Western, southern, and eastern Wisconsin.	9-10				$500,000	Thundersqualls, hail, heavy rain, and wind.	Many buildings demolished and others damaged. Several persons hurt; live stock killed; floods force families to leave homes; interurban and telephone systems crippled.	Official, U. S. Weather Bureau, Green Bay Gazette (Wis.); Star (Washington, D. C.).
Central and western New York.	11	A. m.		1	1,000,000	Wind and rain	Residential and business districts of Syracuse flooded. Pavements, roadways, and bridges washed out. Railway and trolley service stopped; crops devastated.	Official, U. S. Weather Bureau; The Post-Standard (Syracuse, N. Y.); Buffalo Express (N. Y.).
Parkersburg, W. Va	11	P. m.		2		Electrical	High winds and excessive rain	Official, U. S. Weather Bureau.
Newark, Ohio	11	P. m.		3	100,000	Wind	Bathhouse toppled into lake. Eight injured	Washington Post (D. C.).
Dushore, Pa	11	10:30 p. m.	160	1	40,000	Tornado	House and barns wrecked, stock killed, orchards uprooted, and other property damage.	Official, U. S. Weather Bureau.
Owen and Henry Counties, Ky., and vicinity.	11	P. m.		2		Wind and hail	Heavy property damage, trees and telephone lines down. Several persons hurt.	Official, U. S. Weather Bureau; Lexington Leader (Ky.).
Washington, D. C., and vicinity.	11	8 p. m.				Thundersquall	Trees, houses, automobiles injured; some personal injuries.	Washington Post (D. C.).
New York City, N. Y., and vicinity.	11	P. m.		70		do	Heavy property damage. Many lives lost and 100 persons injured.	Official, U. S. Weather Bureau; Express (Buffalo, N. Y.); Boston Post (Mass.).
North Adams, Mass., and vicinity.	11				100,000	Wind and heavy rain.	Buildings flooded. Streets and gardens damaged.	Boston Post (Mass.).
Boston, Mass., and vicinity	11	P. m.		1		Wind and hail	Many persons injured. Houses wrecked, roofs damaged, trees, poles and wires down, cellars flooded. Loss estimated at hundreds of thousands of dollars.	Do.
Portland, Me	12					Wind	Trees uprooted, overhead wires carried away, and traffic delayed.	Official, U. S. Weather Bureau.
Chattanooga, Tenn., and vicinity.	12	1 p. m.			15,000	Wind and rain	General damage done by flooding	Official, U. S. Weather Bureau; Chattanooga News (Tenn.).

Severe Local Storage.—Continued.

Place.	Date.	Time.	Width of path (yards).	Loss of life.	Value of property destroyed.	Character of storm.	Remarks.	Authority.
Flora, Ill.	12				2,400	Wind and hail.	Damage to silos, fences, etc.	Official, U. S. Weather Bureau.
Central Illinois	13	A. m.			75,000	Electrical and wind.	Property damage heavy. Electric light and power service crippled; trees uprooted, crops damaged, roads impassable. Mine wrecked, five persons injured.	Official, U. S. Weather Bureau; Illinois State Register (Springfield, Ill.).
South central Indiana	13				200,000	Wind.	Many buildings destroyed and grain fields and orchards injured.	Official, U. S. Weather Bureau.
St. Paul, Minn.	15	P. m.				Electrical and rain.	Three persons injured. Tracks washed out and other minor damage.	Dispatch (St. Paul, Minn.).
Northwestern Wisconsin	15-16			8	500,000	Tornado and electrical.	Houses and barns destroyed, live stock killed, crops injured, 100 persons injured.	Official, U. S. Weather Bureau; Sentinel (Milwaukee, Wis.).
Antigo, Wis. (near)	16	2:30 p. m.	50 to 100		50,000	Tornado.	Ten farm buildings destroyed, many trees damaged, live stock killed, and crop damage great.	Official, U. S. Weather Bureau.
Lansing, Mich. (near)	16	9:30 p. m.	70		2,500	do.	Buildings damaged; trees broken off.	Do.
Scranton, Pa.	17					Rain.	Heavy rains cause severe property damage, also the tie-up of railroads for several days.	Do.
Valley Station, Ky. (near)	17			4		Electrical.	Four men killed and five injured by lightning.	Do.
North and central New York.	17			2	2,000,000	Electrical and cloudbursts.	Scores of persons injured, and severe property damage by a series of electrical storms and floods.	World (New York); Post-Standard (Syracuse, N. Y.).
Carbondale, Pa., and vicinity.	17-18					Thunderstorms.	Homes, business houses, and mines damaged by floods. Traffic stopped. Damage estimated at millions.	Official, U. S. Weather Bureau; Philadelphia Record (Pa.).
Atlanta, Ga.	18					do.	Electric light, telephone and street car systems out of commission. Trees down, wires broken, basements flooded.	Official, U. S. Weather Bureau.
Memphis, Tenn., and vicinity.	18					Electrical, rain, and wind.	Damage to buildings, trees, etc. Traffic delayed by flood and debris. Estimated damage, thousands of dollars.	Official, U. S. Weather Bureau; Commercial Appeal (Memphis, Tenn.).
Brentwood, Fla.	19				3,000	Thunder and wind.	Damage to fair grounds.	Official, U. S. Weather Bureau.
Springfield, Ky.	19				25,000	Rain.	Considerable damage by washout.	Do.
Macon, Ga.	20					Electrical.	Sewer-pipe works badly damaged.	Do.
Central New York.	21-22					Rain.	Heavy damage from floods.	Press (Binghamton, N. Y.).
Williston, N. Dak., and vicinity.	22-23			1		Rain and wind.	Damage to buildings, trees, etc., and by flooding. Several persons injured.	Official, U. S. Weather Bureau; Williston Herald (N. Dak.).
Bottineau County, N. Dak.	23				300,000	Tornado.	About 50 barns, 30 dwellings, 100 outbuildings, and 50 windmills destroyed.	Williams County Farmers Press (Williston, N. Dak.).
Wichita, Kans.	24	7 p. m.				Wind and rain.	Electric and street-car service interrupted, streets flooded, wheat crop damaged, and live stock killed.	Wichita Eagle (Kans.).
Marshall and Washington Counties, Kans.	25	P. m.				Hail and rain.	Wheat and oat crops total loss.	Official, U. S. Weather Bureau.
Fort Oglethorpe, Ga.	27	4 p. m.		1		Wind.	Walls blown down. Two injured.	Star (Washington, D C.).
Hornell, N. Y., and vicinity.	28-29					Cloudbursts and electrical.	Heavy damage from flooding to tracks, highways, and crops. Barn burned.	Star-Gazette (Elmira, N. Y.).
Goddard, Kans.	29	P. m.				Wind, rain, and hail.	Wheat crop damaged. Telephone systems out of commission.	Wichita Eagle (Kans.).
Adair County, Ky.	29					Electrical and rain.	Crops damaged and several head of cattle killed by lightning.	Official, U. S. Weather Bureau.
Normal, Ill.	30					Wind.	Trees and wires blown down.	Do.

STORMS AND WEATHER WARNINGS.

By EDWARD H. BOWIE, Supervising Forecaster.

TROPICAL STORM IN THE WEST GULF OF MEXICO.

The morning of the 15th meteorological observations by radio from vessels in the southwestern Gulf of Mexico disclosed the presence of a disturbance of moderate intensity central off the port of Tampico, Mexico. This disturbance seemingly had its inception over the southwestern Caribbean Sea on the 12th, although the indications were that it was of but minor intensity. Nevertheless, it caused torrential rains in the vicinity of the Swan Islands during the 12th and 13th. On the 13th there were indications of an imperfectly organized disturbance in the Gulf of Honduras, and moving westward it appeared, as stated before, off Tampico on the morning of the 15th. During its movement westward through British Honduras and Yucatan, press reports tell of torrential rains and unprecedented floods in Salvador, and it is probable that similar conditions prevailed in the adjoining republics, but confirmation of this statement is lacking. Moving northwest from the vicinity of Tampico, the cyclone passed inland during the morning of the 16th immediately south of the Rio Grande and passed up the valley of that river, attended by excessive rains which resulted in unprecedented floods in the lower Rio Grande valley. Northeast storm warnings were displayed at 2 p. m. of the 15th at Brownsville, Tex., and at 10 p. m. at Corpus Christi, Tex., and at the same time advices were issued of heavy rains along the lower Texas coast in the ensuing 24 hours. A report of the floods in the lower Rio Grande Valley will be found elsewhere in this number of the MONTHLY WEATHER REVIEW.

WASHINGTON FORECAST DISTRICT.

In the Washington Forecast District the month was not unusual as to storminess, but rains were frequent and in the North Atlantic States excessive. Few warnings were required; no general displays were ordered for the coastal waters. The disturbances that occurred were of local nature, as, for example, the severe squalls on the Middle Atlantic and New England coasts on the late afternoon of June 11. On the morning of this day small-craft warnings were ordered for the Atlantic coast over and north of Chesapeake Bay, the advices being to the effect that a disturbance of considerable intensity was central north of Lake Ontario and moving eastward and that it would be attended by fresh south and southwest winds and squalls during the afternoon and night of the 11th. The severest of these squalls seems to have occurred in the vicinity of New York City where it did much damage and caused the loss of a considerable number of lives of persons in pleasure boats in the adjacent waters. The

following is an editorial from the *New York Times* on the occurrence of this local windstorm:

In spite of the great amount of damage done by Sunday afternoon's storm, and the many fatalities of which it directly or indirectly was the cause, there is reason for doubting that it was a real tornado—that its brief violence was anything more than an exaggeration of the heavy gust of wind that almost always marks the beginning of an ordinary thundershower. * * * One mystery of the storm was that its approach was unheeded and apparently unseen by the Sunday pleasure seekers whom its arrival was to overwhelm with disaster. Yet they all had been warned, first, by the definite prediction of the Weather Bureau in the morning papers, and, second, by the ominously black clouds that had been gathering in the west for hours.

Small-craft warnings remained displayed through the 12th on the Atlantic coast at and north of Atlantic City, N. J., in connection with the strong westerly winds following the disturbance of the 11th, and on the morning of the 17th small-craft warnings were displayed over the same area, when a disturbance of moderate intensity was over the Great Lakes and moving eastward. Again, on the 21st, small-craft warnings were displayed on the coast at and north of Sandy Hook, N. J., when a disturbance of moderate intensity was central off the New Jersey coast and moving northeastward.

CHICAGO FORECAST DISTRICT.

The Forecast District was unusually free from strong winds and frosts during the month of June, 1922. No storm warnings were issued, but small-craft warnings were issued on the morning of June 11 for the Lower Lakes and on the morning of the 16th for Lakes Superior, Michigan, Huron, and Erie.

On the morning of June 25 an advisory message was sent to the observers in the cranberry marshes in Wisconsin to exercise caution in the marshes that night and to be prepared. Of the four special cranberry-marsh stations, two, Mather and Cranmoor, reported light frost the following morning. The bogs were flooded at these places and damage averted. Critical temperatures were not reached in the cranberry marshes at any other time during the month.—*H. J. Cox.*

NEW ORLEANS FORECAST DISTRICT.

Moderate weather conditions prevailed along the west Gulf coast during the month of June, 1922, and there was no storm without warnings. A disturbance appeared in the west Gulf on the 16th, and storm warnings were displayed from Corpus Christi to the mouth of the Rio Grande River, which the conditions justified.—*I. M. Cline.*

DENVER FORECAST DISTRICT.

Unusually warm and dry weather prevailed in the Denver Forecast District during June, 1922.

No storms of importance crossed the district, and no warnings were issued except for frost in Colorado and northern New Mexico on June 1. Frost temperatures occurred in localities, but no damage was reported.—*Frederick W. Brist.*

SAN FRANCISCO FORECAST DISTRICT.

June, 1922, was a quiet month in this district. No storms from the north Pacific moved inland far enough south to cause more than cloudy weather, and a few light showers on the Washington coast. Thunderstorms were frequent in the northern Plateau from the 6th to the 14th, but the accompanying precipitation was light, and consequently a drought condition prevailed during the month.

Very warm weather prevailed in Nevada on the 24th and 25th, when a record temperature was reported at Tonopah on the 24th, and the highest June temperatures were reported at both Reno and Tonopah on the 25th.

Fire-weather warnings were issued four times during the month, as follows: In Washington, Oregon, and Idaho on the 7th and 23d, and in northern California and Nevada on the 15th and 22d. The warnings issued on the 7th were a failure owing to the occurrence of thunderstorms that afternoon and night causing a drop in temperature. The warnings of the 15th, 22d, and 23d were both timely and highly justified.—*G. H. Willson.*

RIVERS AND FLOODS.

By H. C. Frankenfield, Meteorologist.

SUMMARY OF THE SPRING FLOODS OF 1922, IN THE MISSISSIPPI DRAINAGE BASIN.

Owing to the wide distribution of frequent and heavy rains there were floods throughout the entire Mississippi Basin except in the Missouri River and tributaries above Kansas City, Mo., and in the Mississippi River north of St. Paul, Minn. In the upper Mississippi Valley the floods, except that of the Illinois River, while not extremely high, were sufficiently so as to cause much apprehension as well as considerable damage. Records were not exceeded in the Mississippi River except at Muscatine, Iowa, where the crest stage on April 24, was 19.5 feet, or 1.5 feet above the previous high-water record of April 8, 1920.

The greatest floods that occurred above Cairo, Ill., were those in the Illinois, White, and Wabash Rivers, especially the Illinois. Over many portions of this river the crest stages were the highest of record, some even exceeding those of the great flood of 1844. The most disastrous overflow occurred at Beardstown, Ill., and vicinity through the breaking of a levee, and about 200,000 acres of cultivated lands were covered. The crest stage on April 20, at this place was 25.1 feet, or 2.6 feet above the previous high-water record of June, 1844.

The lower Mississippi River floods exceeded all previous records below the mouth of the Arkansas River. The river reached the flood stage of 45 feet at Cairo on March 16, and passed below the flood stage of 18 feet at New Orleans, La., on June 4. However, at Baton Rouge, La., the river did not fall below the flood stage of 35 feet until June 12, and below the flood stage of 28 feet at Donaldsonville, La., until June 10, the return of crevasse water holding the waters at high stage.

There were four crevasses of importance. The greatest one, known as the Weecama Crevasse, occurred on April 26, on the right bank of the Mississippi River near Ferriday, La. The next in order of importance occurred on April 27, on the left bank of the Mississippi River at Poydras, La., 14 miles below New Orleans; the third in the right bank of the Atchafalaya system over Bayou des Glaises, about one-half mile below Hamburg, La., in Avoyelles Parish, and the fourth on April 22, on the right bank of the Mississippi River at Myrtle Grove, La., 25 miles below New Orleans.

The levees surrounding the State farm at Angola, La., also gave way on May 17, and the farm was overflowed.

About 13,200 square miles of land were overflowed during the floods, about 4,400 less than in 1912, almost all of the 1922 deficiency occurring in the Vicksburg,

Miss., district, which extends from the mouth of the White River to Vicksburg, and includes the Yazoo River.

The record of loss and damage is very incomplete, and data from one of the largest districts are not yet available. Figures thus far received show a loss of more than $17,000,000, of which more than one-half was in prospective crops, and it is probable that later information will increase the above total by a few millions of dollars at least.

A complete report of these floods will shortly appear in another publication.

The table following gives the stages reached at river stations during the floods:

Stages during spring floods of 1922.

River and station.	Flood stage.	Above flood stages—dates.		Crest.	
		From—	To—	Stage.	Date.
Mississippi:	*Feet.*			*Feet.*	
La Crosse, Wis	12	Apr. 12	Apr. 21	13.7	Apr. 17.
Prairie du Chien, Wis	18	Apr. 17	Apr. 22	19.4	Apr. 19.
Dubuque, Iowa	18	...do...	Apr. 26	21.0	Apr. 20-21.
Clinton, Iowa	16	Apr. 18	Apr. 29	19.0	Apr. 22-23.
Le Claire, Iowa	10	Apr. 17	Apr. 30	12.9	Apr. 23.
Davenport, Iowa	15	Apr. 19	Apr. 28	17.1	Do.
Muscatine, Iowa	16	...do...	Apr. 29	19.5	Apr. 24.
Keokuk, Iowa	14	Apr. 15	May 3	17.6	Apr. 23.
Warsaw, Ill	17	...do...	May 2	20.2	Apr. 24
Quincy, Ill	14	Apr. 14	May 5	18.7	Apr. 25.
Hannibal, Mo	13	Apr. 12	May 8	18.9	Do.
Louisiana, Mo	12	Mar. 16	Mar. 16	12.3	Mar. 16.
Do	12	Apr. 10	May 8	17.0	Apr. 26-27.
Grafton, Ill	18	Mar. 17	Mar. 17	18.4	Mar. 17.
Do	18	Apr. 1	Apr. 4	19.4	Apr. 2.
Do	18	Apr. 7	May 9	25.8	Apr. 20.
Alton, Ill	21	Mar. 16	Mar. 19	23.0	Mar. 17.
Do	21	Mar. 27	May —	31.5	Apr. 19-20.
St. Louis, Mo	30	Apr. 10	Apr. 23	34.0	Apr. 19.
Chester, Ill	27	Apr. 3	Apr. 3	27.0	Apr. 3.
Do	27	Apr. 9	May 3	34.0	Apr. 20-21.
Cape Girardeau, Mo	30	Mar. 28	May 5	38.0	Apr. 21-22.
New Mardrid, Mo	34	Mar. 16	May 9	41.7	Apr. 26-27.
Memphis, Tenn	35	Mar. 20	May 13	42.6	Mar. 31-Apr. 1.
Helena, Ark	42	Mar. 19	May 18	53.1	May 3.
Arkansas City, Ark	48	Mar. 17	May 23	58.0	Apr. 22-27.
Greenville, Miss	42	Mar. 28	May 22	52.1	Apr. 25-27
Vicksburg, Miss	45	...do...	May 30	55.0	Apr. 28-29.
Natchez, Miss	46	Mar. 31	June 2	55.5	Apr. 26.
Baton Rouge, La	35	Apr. 2	June 12	45.7	May 16.
Donaldsonville, La	28	Apr. 1	June 10	35.9	Do.
New Orleans, La	18	Mar. 31	June 4	22.7	Apr. 24.
Ohio:					
Portsmouth, Ohio	50	Mar. 17	Mar. 17	51.0	Mar. 17.
DamNo.35,Oneonta,Ky	45	...do...	Mar. 19	46.6	Mar. 18.
Cincinnati, Ohio	50	Mar. 16	Mar. 20	52.2	Do.
Madison, Ind	46	Mar. 19	Mar. 19	46.1	Mar. 19.
Louisville, Ky	28	Mar. 16	Mar. 21	30.2	Do.
Cloverport, Ky	40	...do...	Mar. 24	46.4	Mar. 20.
Do	40	Apr. 21	Apr. 22	40.1	Apr. 21-22.
Evansville, Ind	35	Mar. 14	Mar. 28	42.9	Mar. 21.
Do	35	Apr. 5	Apr. 10	36.6	Apr. 7.
Do	35	Apr. 20	Apr. 26	37.6	Apr. 23.
Henderson, Ky	33	Mar. 15	Mar. 28	41.3	Mar. 21-22.
Do	33	Apr. 5	Apr. 10	34.7	Apr. 8.
Do	33	Apr. 20	Apr. 26	35.9	Apr. 23.
Dam No. 48, Indiana	42	Mar. 15	Mar. 28	49.5	Mar. 22.
Do	42	Apr. 6	Apr. 9	42.7	Apr. 8.
Do	42	Apr. 21	Apr. 26	44.1	Apr. 24.
Mount Vernon, Ind	35	Mar. 15	Mar. 30	43.5	Mar. 23.
Do	35	Apr. 5	Apr. 12	37.5	Apr. 9.
Do	35	Apr. 19	Apr. 28	39.5	Apr. 24.
Shawneetown, Ill	35	Mar. 15	May 1	47.6	Mar. 25.
Paducah, Ky	43	Mar. 17	Mar. 31	48.8	Mar. 24.
Do	43	Apr. 24	Apr. 29	44.0	Apr. 26.
Cairo, Ill	45	Mar. 16	May 7	53.6	Mar. 25-27.
Conemaugh-Kiskiminetas:					
Saltsburg, Pa	8	Apr. 16	Apr. 16	9.5	Apr. 16.
Muskingum:					
Zanesville, Ohio	25	Apr. 15	...do...	25.7	Apr. 15.
McConnellsville, Ohio	22	...do...	...do...	25.0	Apr. 16
Tuscarawas:					
Norris Point, Ohio	8	Mar. 31	Apr. 2	8.6	Apr. 1.
Do	8	Apr. 15	Apr. 19	11.7	Apr. 16.
Coshocton, Ohio	8	...do...	...do...	11.4	Do.
Walhonding:					
Walhonding, Ohio	8	Apr. 15	Apr. 16	11.2	Apr. 15.
Do	8	Apr. 18	Apr. 18	9.0	Apr. 18.
Do	8	May 20	May 20	9.0	May 20.
Hocking:					
Athens, Ohio	17	Mar. 15	Mar. 16	19.8	Mar. 16.
Do	17	Apr. 15	Apr. 16	21.9	Apr. 16.
Scioto:					
Larue, Ohio	11	Apr. 1	Apr. 1	11.8	Apr. 1.
Do	11	Apr. 15	Apr. 16	13.5	Apr. 15.
Do	11	Apr. 18	Apr. 19	14.0	Apr. 18.
Do	11	May 20	May 21	12.0	May 20.
Do	11	May 27	May 27	12.0	May 27.

Stages during spring floods of 1922—Continued.

River and station.	Flood stage.	Above flood stages—dates.		Crest.	
		From—	To—	Stage.	Date.
Scioto—Continued.	*Feet.*			*Feet.*	
Prospect, Ohio	10	Apr. 1	Apr. 1	10.3	Apr. 1.
Do	10	Apr. 19	Apr. 20	11.7	Apr. 19.
Circleville, Ohio	10	Mar. 15	Mar. 16	11.7	Mar. 16.
Do	10	Apr. 1	Apr. 1	10.0	Apr. 1.
Do	10	Apr. 15	Apr. 17	14.6	Apr. 16
Do	10	May 28	May 28	11.0	May 28.
Chillicothe, Ohio	16	Mar. 16	Mar. 16	16.5	Mar. 16.
Do	16	Apr. 15	Apr. 17	20.5	Apr. 16.
Stillwater:					
Pleasant Hill, Ohio	13	...do...	Apr. 15	13.2	Apr. 15.
Kentucky:					
Beattyville, Ky	30	Mar. 11	Mar. 11	31.2	Mar. 11.
Green:					
Lock No. 6, Brownsville, Ky	30	Mar. 4	Mar. 5	32.4	Mar. 5.
Do	30	Mar. 17	Mar. 17	30.5	Mar. 17.
Lock No. 4, Woodbury, Ky	33	Mar. 3	Mar. 8	40.7	Mar. 5.
Do	33	Mar. 11	Mar. 20	40.4	Mar. 17.
Do	33	Apr. 3	Apr. 3	33.0	Apr. 3.
Lock No. 2, Rumsey, Ky	34	Feb. 25	Mar. 2	35.6	Feb. 28.
Do	34	Mar. 6	Mar. 30	40.8	Mar. 21-22.
Big Barren:					
Bowling Green, Ky	20	Mar. 3	Mar. 3	25.3	Mar. 3.
Wabash:					
Bluffton, Ind	12	Apr. 19	Apr. 20	13.4	Apr. 19.
Lafayette, Ind	11	Mar. 12	Mar. 18	17.4	Mar. 16.
Do	11	Mar. 29	Apr. 6	21.0	Apr. 2.
Do	11	Apr. 9	Apr. 23	20.7	Apr. 18.
Terre Haute, Ind	16	Mar. 15	Mar. 23	19.7	Mar. 16.
Do	16	Apr. 1	Apr. 26	24.4	Apr. 19.
Vincennes, Ind	14	Mar. 17	Mar. 29	18.9	Mar. 21.
Do	14	Mar. 31	Apr. 30	23.0	Apr. 21-22.
Mount Carmel, Ill	15	Mar. 16	May 2	26.0	Apr. 23.
Do	15	May 4	May 4	15.1	May 4.
White:					
Decker, Ind	18	Mar. 18	Mar. 28	24.6	Mar. 22.
Do	18	Mar. 31	Apr. 27	25.7	Apr. 22.
Georgetown, Ark	22	Mar. 17	Mar. 22	22.4	Mar. 21.
Do	22	Mar. 31	Apr. 24	23.9	Apr. 6-11.
East Fork of White:					
Williams, Ind	10	Mar. 18	Mar. 23	15.4	Mar. 19.
Do	10	Apr. 3	Apr. 5	11.8	Apr. 4.
Do	10	Apr. 15	Apr. 22	17.4	Apr. 19.
Shoals, Ind	20	Mar. 19	Mar. 23	26.3	Mar. 20.
Do	20	Apr. 3	Apr. 6	22.5	Apr. 5.
Do	20	Apr. 15	Apr. 23	28.0	Apr. 19.
West Fork of White:					
Anderson, Ind	12	Mar. 15	Mar. 16	12.1	Mar. 15.
Do	12	Apr. 1	Apr. 1	12.2	Apr. 1.
Do	12	Apr. 11	Apr. 12	12.8	Apr. 11.
Do	12	Apr. 15	Apr. 16	17.5	Apr. 15.
Do	12	Apr. 18	Apr. 19	14.7	Apr. 18.
Noblesville, Ind	14	Mar. 16	Mar. 16	14.0	Mar. 16.
Do	14	Apr. 12	Apr. 12	14.7	Apr. 12.
Do	14	Apr. 15	Apr. 16	17.3	Apr. 16.
Do	14	Apr. 18	Apr. 19	15.4	Apr. 18.
Elliston, Ind	19	Mar. 15	Mar. 22	26.3	Mar. 17.
Do	19	Mar. 31	Apr. 5	24.5	Apr. 3.
Do	19	Apr. 9	Apr. 23	27.0	Apr. 20.
Cumberland:					
Carthage, Tenn	40	Mar. 3	Mar. 6	44.0	Mar. 4.
Do	40	Mar. 12	Mar. 16	43.5	Mar. 12.
Nashville, Tenn	40	Mar. 3	Mar. 20	45.1	Do.
Clarksville, Tenn	46	Mar. 4	Mar. 21	51.3	Mar. 16.
French Broad:					
Penrose, N. C	13	Mar. 28	Mar. 28	14.1	Mar. 28.
Tennessee:					
Knoxville, Tenn	12	Mar. 11	Mar. 12	13.0	Mar. 12.
Gunthersville, Ala	31	Mar. 15	Mar. 15	31.0	Mar. 15.
Florence, Ala	18	Mar. 3	Mar. 8	20.0	Mar. 5.
Do	18	Mar. 10	Mar. 18	21.5	Mar. 11.
Savannah, Tenn	40	...do...	Mar. 21	43.5	Mar. 16.
Riverton, Ala	32	Mar. 3	Mar. 22	42.8	Mar. 11.
Johnsonville, Tenn	31	Mar. 7	Mar. 7	31.0	Mar. 7.
Do	31	Mar. 10	Mar. 24	36.4	Mar. 15.
North Fork of Holston:					
Mendota, Va	8	Mar. 11	Mar. 11	8.2	Mar. 11.
Do	8	Mar. 16	Mar. 16	8.7	Mar. 16.
Hiwassee:					
Charleston, Tenn	22	Mar. 11	Mar. 11	22.6	Mar. 11.
Duck:					
Columbia, Tenn	30	Mar. 2	Mar. 3	32.0	Mar. 3.
Do	30	Mar. 10	Mar. 11	31.4	Mar. 11.
Wisconsin:					
Merrill, Wis	11	Apr. 11	Apr. 11	11.0	Apr. 11.
Knowlton, Wis	12	Apr. 5	Apr. 13	18.6	Do.
Wisconsin Rapids, Wis	12	Apr. 11	Apr. 12	13.5	Do.
Portage, Wis	14	...do...	Apr. 17	15.8	Apr. 14.
Des Moines:					
Ottumwa, Iowa	10	May 27	May 27	10.0	May 27.
Illinois:					
Morris, Ill	13	Mar. 21	Mar. 22	13.6	Mar. 21.
Do	13	Mar. 31	Apr. 22	20.1	Apr. 12.
Peru, Ill	14	Mar. 13	May 12	23.8	Apr. 13.
Do	14	May 27	June 1	15.0	May 28.
Henry, Ill	7	Mar. 12	June 11	18.0	Apr. 15-16.
Peoria, Ill	16	Mar. 19	May 14	24.8	Apr. 15.
Havana, Ill	14	Mar. 20	May 19	22.6	Apr. 20.
Beardstown, Ill	12	Mar. 14	June 12	25.1	Do.
Pearl, Ill	12	Mar. 16	May 22	23.0	Apr. 19.

Stages during spring floods of 1922—Continued.

River and station.	Flood stage.	Above flood stages—dates.		Crest.	
		From—	To—	Stage.	Date.
Missouri:	*Feet.*			*Feet.*	
Hermann, Mo.	21	Apr. 8	Apr. 20	24.7	Apr. 18.
St. Charles, Mo.	25	Mar. 27	Mar. 27	25.4	Mar. 27.
Do.	25	Apr. 1	Apr. 2	26.5	Apr. 1.
Do.	25	Apr. 8	Apr. 22	30.8	Apr. 13, 19.
Grand:					
Chillicothe, Mo.	18	Apr. 10	Apr. 11	19.1	Apr. 10.
Brunswick, Mo.	10	...do.....	Apr. 14	12.6	Apr. 11-12.
James:					
Huron, S. Dak.	9	Mar. 16	May 8	16.5	Mar. 22.
Do.	9	May 12	May 29	11.4	May 19-21.
Osage:					
Osceola, Mo.	20	Mar. 10	Mar. 22	21.8	Mar. 20.
Do.	20	Mar. 31	Apr. 2	21.6	Apr. 2.
Do.	20	Apr. 8	Apr. 21	28.8	Apr. 10.
Warsaw, Mo.	22	Mar. 15	Mar. 22	26.7	Mar. 15.
Do.	22	Mar. 31	Apr. 6	26.8	Apr. 4.
Do.	22	Apr. 8	Apr. 22	34.9	Apr. 12.
Do.	22	Apr. 28	Apr. 30	25.3	Apr. 28.
Tuscumbia, Mo.	25	Mar. 17	Mar. 22	26.0	Mar. 21.
Do.	25	Mar. 31	Apr. 23	37.7	Apr. 17.
Do.	25	Apr. 29	May 1	27.4	Apr. 30.
Meramec:					
Steelville, Mo.	12	Apr. 18	Apr. 18	13.1	Apr. 18.
Pacific, Mo.	11	Mar. 16	Mar. 17	12.7	Mar. 16.
Do.	11	Mar. 28	Mar. 29	12.2	Mar. 28.
Do.	11	Apr. 1	Apr. 3	17.9	Apr. 3.
Do.	11	Apr. 11	Apr. 13	12.3	Apr. 11.
Do.	11	Apr. 17	Apr. 20	17.4	Apr. 20.
Do.	11	Apr. 30	Apr. 30	12.6	Apr. 30.
Valley Park, Mo.	14	Apr. 1	Apr. 4	21.0	Apr. 3.
Do.	14	Apr. 11	Apr. 13	14.8	Apr. 12.
Do.	14	Apr. 15	Apr. 21	22.8	Apr. 19.
Bourbeuse:					
Union, Mo.	10	Mar. 15	Mar. 16	11.3	Mar. 16.
Do.	10	Mar. 28	Mar. 28	11.6	Mar. 28.
Do.	10	Apr. 1	Apr. 3	14.4	Apr. 2.
Do.	10	Apr. 17	Apr. 19	13.6	Apr. 19.
St. Francis:					
Marked Tree, Ark.	17	Mar. 28	May 3	19.3	Apr. 15-17.
Yazoo:					
Yazoo City, Miss.	25	Mar. 21	June 14	31.9	Apr. 29-May 1, 4-6.
Tallahatchie:					
Swan Lake, Miss.	25	Mar. 5	Apr. 30	29.2	Mar. 19-21.
Do.	25	May 3	May 29	27.7	May 13-17.
Red:					
Fulton, Ark.	28	Apr. 8	Apr. 10	28.5	Apr. 9.
Do.	28	May 1	May 2	28.4	May 2.
Do.	28	May 15	May 16	28.4	May 16.
Alexandria, La.	36	Apr. 12	Apr. 23	37.1	Apr. 18-20.
Do.	36	May 5	May 25	37.4	May 10.
Ouachita:					
Camden, Ark.	30	Mar. 30	Apr. 13	36.2	Apr. 4.
Do.	30	Apr. 30	May 4	32.4	May 2.
Monroe, La.	40	Apr. 11	May 29	42.3	May 9-11.
Atchafalaya:					
Simmesport, La.	41	Apr. 6	June 12	51.9	May 16.
Melville, La.	37	Apr. 1	June 14	45.9	May 14-16.
Smoky Hill:					
Lindsborg, Kans.	19	Apr. 26	Apr. 27	21.4	Apr. 27.
Arkansas:					
Wichita, Kans.	9	Mar. 15	Mar. 16	10.2	Mar. 15.
Do.	9	Apr. 9	Apr. 10	9.9	Apr. 9.
Fort Smith, Ark.	22	Apr. 10	Apr. 17	27.8	Apr. 12.
Dardanelle, Ark.	20	Apr. 11	Apr. 18	25.2	Apr. 13.
Little Rock, Ark.	23	Apr. 14	Apr. 15	23.3	Apr. 14.
Pine Bluff, Ark.	25	...do.....	Apr. 17	26.0	Apr. 16.
Neosho:					
Neosho Rapids, Kans.	22	Apr. 10	Apr. 11	24.4	Apr. 11.
Le Roy, Kans.	24	Mar. 25	Mar. 25	24.8	Mar. 25.
Do.	24	Apr. 9	Apr. 11	27.4	Apr. 9.
Iola, Kans.	10	Mar. 18	Mar. 18	10.2	Mar. 18.
Do.	10	Mar. 25	Mar. 26	18.4	Mar. 26.
Do.	10	Apr. 9	Apr. 13	19.2	Apr. 10.
Oswego, Kans.	17	Apr. 5	Apr. 17	23.8	Apr. 9.
Wyandotte, Okla.	23	Apr. 10	Apr. 10	23.5	Apr. 10.
Fort Gibson, Okla.	22	...do.....	Apr. 17	30.0	Apr. 11.
Do.	22	Apr. 19	Apr. 19	22.4	Apr. 19.
Cottonwood:					
Emporia, Kans.	20	Apr. 10	Apr. 12	22.9	Apr. 11.
North Canadian:					
Woodward, Okla.	3	Mar. 11	Mar. 11	3.2	Mar. 11.
Do.	3	Mar. 13	Mar. 23	6.0	Mar. 15.
Do.	3	Apr. 5	Apr. 10	3.4	Apr. 8.
Do.	3	Apr. 25	May 13	5.0	Apr. 25.
Canton, Okla.	3	Mar. 15	Mar. 17	4.1	Mar. 16.
Do.	3	Apr. 26	Apr. 26	3.7	Apr. 26.
Oklahoma City, Okla.	12	Mar. 22	Mar. 22	12.1	Mar. 22.
Do.	12	Apr. 10	Apr. 10	12.6	Apr. 10.
Little Arkansas:					
Sedgwick, Kans.	18	Mar. 14	Mar. 15	23.4	Mar. 14.
Do.	18	Apr. 8	Apr. 9	23.5	Apr. 9.
Petit Jean:					
Danville, Ark.	20	Mar. 31	Apr. 3	22.7	Apr. 2.
Do.	20	Apr. 6	Apr. 9	22.6	Apr. 7.
Do.	20	May 5	May 6	21.0	May 5.
Do.	20	May 8	May 9	20.6	May 9.
White:					
Newport, Ark.	26	Apr. 13	Apr. 14	26.2	Apr. 13-14.
Georgetown, Ark.	22	Mar. 17	Mar. 22	22.4	Mar. 21.
Do.	22	Mar. 31	Apr. 24	23.9	Apr. 6-9, 11, 15.
Clarendon, Ark.	30	Apr. 7	Apr. 27	30.7	Apr. 11-21.
Black:					
Black Rock, Ark.	14	Mar. 10	May 8	23.4	Apr. 9.
Cache:					
Patterson, Ark.	9	Mar. 11	Apr. 19	10.3	Apr. 1.
Sulphur:					
Finley, Tex.	24	Mar. 31	Apr. 16	26.4	Apr. 2-3.
Do.	24	Apr. 27	May 6	28.2	Apr. 30.
Do.	24	May 15	May 18	25.0	May 15-16.
Ringo Crossing, Tex.	20	Mar. 27	Mar. 28	22.5	Mar. 27.
Do.	20	Apr. 6	Apr. 10	23.0	Apr. 6.
Do.	20	Apr. 26	May 2	23.8	Apr. 28.
Do.	20	May 10	May 13	24.4	May 11.
Cypress:					
Jefferson, Tex.	18	Apr. 2	Apr. 8	21.6	Apr. 4.
Do.	18	Apr. 27	May 5	20.5	Apr. 28.

THE FLOODS OF JUNE, 1922.

The great outstanding floods of the month of June occurred in the lower Rio Grande and the following report thereon was prepared by Mr. J. H. Jarboe, meteorologist, San Antonio, Tex.:

The flood in the Rio Grande during June, 1922, will long be remembered. The great magnitude of the flood, together with the season and manner of its occurrence tend to make it epochal.

On the night of June 15 a tropical storm of moderate intensity entered Mexico below the mouth of the Rio Grande. The progress of the storm could be followed to a certain extent by the heavy rains along the river. However, when the storm reached the higher elevations of northern Mexico, very heavy rains resulted, and the resultant runoff produced serious flood conditions in two separate portions of the Rio Grande.

The flood waters reached the Rio Grande first from the San Juan, a tributary from Mexico entering the river just above Rio Grande City, Tex. The river rose at this station to 26.5 feet, a stage exceeding by 0.3 foot the great flood of September, 1919. A second rise caused by water coming down the main channel of the Rio Grande took the stage at Rio Grande City to 29.5 feet, 14.5 feet above flood stage, on June 22. This is the highest stage reached at this station since 1909, when the estimated stage was 30 feet.

The water that caused the record rises came into the river above Eagle Pass, where the river reached a stage of 45.6 feet on the 19th, or 29.6 feet above flood stage. The Southern Pacific and International bridges were washed away, and stores and houses on the west side of Commercial Street were damaged. At Piedras Negras, the town on the Mexican side of the river, several blocks of houses were destroyed. The crest moved rapidly downstream between high river banks with stage at Laredo of 43.9 feet, 15.9 feet above flood stage, on the 20th. The flood reached the lower Rio Grande while the river was still swollen by water from the San Juan. Two crests moved toward the Gulf, but the flat nature of the Lower Valley, with a fall of less than a foot to the mile, together with the many levees built in recent years, caused the crests of the two floods to merge into one, producing unprecedented conditions. The crest stage at Mission, Tex., was 28.4 feet, 4.4 feet above flood stage, on the 23d.

Upon receipt of flood warnings new levees were built and old ones strengthened, foundations of pumping plants were reenforced, and everything possible was done to protect property. In many places the water swept entirely over the main levees causing great damage to wide sections of agricultural lands. The flooded districts ranged in width from 6 to 20 miles across Hidalgo County; and 20 to 40 miles across Cameron County. A corresponding inundation occurred in Mexico. Not all the ground in this triangle was submerged, however, as many sections remained above the water line.

Flood stage was reached at all stations, and the river was out of its banks 2 days at Laredo, 4 days at Eagle Pass, 7 days at Mission, and 12 days at Rio Grande City. Stages recorded at Del Rio, Eagle Pass, and Laredo, were the highest ever known to have occurred.

It is estimated that 30,000 acres of agricultural lands were inundated with loss of crops. There was much damage to levees, bridges, roads, irrigation systems, transportation lines, and buildings of all kinds. Many towns from the western border of Hidalgo County to the Gulf suffered complete or partial inundation, with great property losses. Rail communication to the lower Rio Grande Valley and throughout the valley was broken. Mail service by boat was inaugurated, and airplanes used.

Much damage would have resulted from the great overflow at any time of the year, but the flood, coming as it did in the height of the growing season, destroyed $2,000,000 worth of crops. Another million will have to be spent to repair levees, roads, buildings, and to put the irrigation systems in working order.

Few, if any, lives were lost on the American side of the Rio Grande, which is remarkable when the magnitude of the flood is considered.

From incomplete reports it is impossible to express the money value of the flood warnings issued. Lives and much property were saved by the warnings, and the people have repeatedly expressed their appreciation.

Advisory warnings for the lower Rio Grande Valley were issued on June 12. The warnings were based on a rapid rise in the river at Rio Grande City. Advisory warnings were again issued on the 13th, and almost daily thereafter. On June 17, flood warnings were issued, and people were advised to use every precaution to protect their property. The river rose steadily at Mission from this date on, reaching flood stage on the 19th, with the crest passing on the 23d.

On June 17 a very rapid rise developed in the Rio Grande in the Del Rio section. This flood quickly reached serious proportions, with a crest stage at Del Rio of 32.3 feet, which is 3.6 feet above the record flood of 1919.

The action of our river observer at Eagle Pass in giving warning to the many people living in the low sections around the city is commendable. The warnings were quickly disseminated, although but little time was available, and more than 2,000 people with most of their personal property moved to higher ground.

The Southern Pacific and the International bridges went out before midnight, but the crest at Eagle Pass was not reached until 2 a. m. on the 19th. A stage of 45.6 feet was recorded. This is 5.2 feet higher than the previous record flood of June 14, 1889.

It took the flood wave 35 hours to run from Eagle Pass to Laredo, a distance of 127 miles. The people at Laredo were warned well in advance of the rise. The river banks are high at Laredo, and no great damage resulted. The river reached a stage of 43.9 feet at 1 p. m. on the 20th, which is 9.9 feet higher than the previous record flood of September, 1919. The new International highway bridge was completely submerged. Approaches to the bridge were damaged to the extent of several thousand dollars, but the main structure stood intact.

Two days later, June 22, the crest of the flood was at Rio Grande City, with a stage of 29.5 feet. This is just 2 feet lower than the previous record flood of 1872. Great overflows resulted in this section with corresponding damage to growing crops.

The crest was 30 hours running from Rio Grande City to Mission, a distance of 32 miles; here a stage of 28.4 feet resulted. This is 1.9 feet lower than the previous record flood of September 7, 1909.

The Arroyo Colorado, an old river bed of the Rio Grande, begins in the west portion of Hidalgo County and extends eastward across Cameron County to the Gulf, a distance of about 90 miles. When the Rio Grande reaches a stage of 22 feet at Mission, oveflow starts through the Arroyo Colorado, as well as through old channels on the Mexican side of the river. Great volumes of water passed through the Arroyo Colorado during this flood; in fact, the main channel of the river carried only a small portion of the discharge. Levees that have been built in recent years near the Arroyo checked and diverted the water in many places. This resulted in submerging sections never before subject to flood. Points in Cameron County 40 miles north of the Rio Grande were under water. At the end of the month the water had not entirely subsided.

Following is a comparison of the highest known stages of the Rio Grande with the stages recorded in the flood of June, 1922:

Station.	Highest of record.	Stage reached June, 1922.
Del Rio, Tex	28.7 feet, Sept. —, 1919	32.3 feet, 18th.
Eagle Pass, Tex	40.4 feet, June 14, 1889	45.6 feet, 19th.
Laredo, Tex	34.0 feet, Sept. 19, 1919	43.9 feet, 20th.
Rio Grande City, Tex	31.5 feet, ——, —, 1872	29.5 feet, 22d.
Mission, Tex	30.3 feet, Sept. 7, 1909	28.4 feet, 23d.

East of the Rocky Mountains there were no other floods of importance in rivers of any consequence, but there were several floods in smaller streams caused by torrential local rains. These occurred over many districts east of the Mississippi River and were very destructive both in rural and urban communities. The rainfall was heaviest and the floods severe over the drainage basins of the Susquehanna and Delaware Rivers within the State of New York. At Syracuse, the rainfall for the month of June was 15.92, at Cortland, 15.04, at New Berlin, 10.59, and at Port Jervis, 11.03 inches. The first heavy rains occurred on June 2 and 3 and in a very short time the volume of water was far in excess of the carrying capacity of the small streams. Houses, factories, bridges, railroad tracks and State highways were destroyed and thousands of acres of land overflowed, the flooded area extending through the Lackawanna Valley of extreme northeastern Pennsylvania.

The main streams were not seriously affected, although the Susquehanna above Binghamton and its larger tributaries were from 2 to 3.5 feet above flood stages on June 12 and 13.

The next severe local flood occurred on June 9, in the town of Frederick, Md., and the adjacent country. A heavy rain during the previous evening was followed in the early morning by a terrific downpour, and soon Carroll Creek, which runs through Frederick, overflowed its banks. Streets and houses were flooded, and cattle and other property swept away, the losses and damage amounting to many thousands of dollars.

On June 10, excessive rains in Wisconsin soon caused all the smaller streams to overflow their banks, with resulting casualties similar to those that had visited the east a few days earlier. The sections immediately south and west of Green Bay suffered most, crop losses predominating, although railroad losses were also heavy.

The next visitation of torrential rains occurred on June 18 and 19, over portions of eastern New York, northeastern Pennsylvania and New England. At Port Jervis, N. Y., on the Delaware River, the rainfall for the 24 hours ending at 8 a. m., June 18, was 6.78 inches, of which, according to press reports, 5.5 inches fell in five hours during the early hours of June 18.

Hundreds of families were driven from their homes, houses were floated from their foundations, industrial plants were flooded and railroad tracks and highways destroyed. In the streets of the town the waters were from five to ten feet deep. Damage of a similar character, but less extensive was also reported at Westfield in northern Vermont.

The last floods centered in the vicinity of Broome Co., New York, following the heavy rains of the night of June 28. This flood was not as severe as its precedessors, and the damage was proportionately less.

In all, the damage caused by these "cloudbursts" in New York and Pennsylvania, amounted to about $4,000,000, to which must be added the large total of intangible losses occasioned by the enforced delay in farming operations.

As a rule the southern floods were not severe. The Ocmulgee River of Georgia was in flood early in the month with considerable resulting damage, and there was a severe local flood in New River, Tenn., caused by very heavy rains during the night of June 13–14. Lowlands, fences, and crops were destroyed and roads blocked, and a Southern Railway passenger train was wrecked by running into a washout.

The Colorado River at Yuma, Ariz., after reaching a crest of 27.4 feet on June 10, or 2.4 feet above the flood stage, began to fall slowly, although there was a slight recovery to the flood stage from June 18 to 23, inclusive.

The flood in the San Joaquin River of California, caused by the rapid melting of the snows in the mountains, were the highest in recent years, and did damage to crops, in hand and prospective, to an estimated amount of $710,000. In all about 18,500 acres of cultivated lands were overflowed. There were also numerous breaks in the levees.

Regarding these losses, Mr. W. E. Bonnett, meteorologist, Fresno, Calif., commented as follows:

The greater portion of the losses occasioned by floods in this district, beginning in the latter part of May and continuing during the first half

of June, were occasioned by unwise encroachments on some natural flood reservoirs, and in order that the cause and effect may be better understood some explanation of conditions in the Tulare Lake Basin is presented.

The original area of the Tulare Lake Basin was approximately 400,000 acres of which about 360,000 have been reclaimed behind levees that are adequate to protect against more than normal run-off from King River. After a series of dry seasons the remainder of the lake bed becomes dry and the extremely fertile soil makes it a particularly alluring field for big returns from a comparatively small outlay.

Flood waters from the Kings first entered the dry lake bed on May 23 and more or less of the surplus waters continued to pour into the lake until about the same date in June, although the maximum area of grain land had been submerged by June 4.

Warning had been issued at the end of the snowfall season in April that high water might be expected in June.

The crest of the annual rise of the Columbia River was reached during the month, although at its close the river was still generally above the flood stage. A report on the flood should be ready for the MONTHLY WEATHER REVIEW for July, 1922.

In Alaska the abnormally high temperatures of June melted the snow and ice so rapidly that some floods occurred in the upper Yukon and its tributaries. Press reports stated that overflow waters from the Klondike River inundated the town of Bear Creek, near Dawson, to the depth of 2 feet, and the inhabitants were driven to the hills.

Flood stages during June, 1922.

River and station.	Flood stage.	Above flood stages—dates.		Crest.	
		From—	To—	Stage.	Date.
ATLANTIC DRAINAGE.					
Connecticut:	*Feet.*			*Feet.*	
White River Junction, Vt.	13	22	24	13.6	23
Do.	13	30	(1)	14.9	30
Susquehanna:					
Oneonta, N. Y.	12	12	12	14.1	12
Unadilla:					
New Berlin, N. Y.	8	12	13	11.5	12
Do.	8	23	24	9.7	23
Chenango:					
Sherburne, N. Y.	8	12	12	8.9	12
Neuse:					
Neuse, N. C.	14	5	5	15.8	5
Santee:					
Rimini, S. C.	12	(2)	17	14.7	8
Do.	12	22	25	12.9	25
Ferguson, S. C.	12	(2)	19	13.5	8-9
Do.	12	24	27	12.4	26
Broad:					
Blairs, S. C.	15	3	3	15.5	3
Ocmulgee:					
Macon, Ga.	18	2	4	22.3	2
Abbeville, Ga.	11	6	14	14.7	8-9
Lumber City, Ga.	15	11	14	16.0	12 5
EAST GULF DRAINAGE.					
Apalachicola:					
River Junction, Fla.	12	(2)	16	20.5	5
Blountstown, Fla.	15	(2)	16	20.5	5
MISSISSIPPI DRAINAGE.					
Walhonding:					
Walhonding, Ohio	8	17	17	8.8	17
New:					
New River, Tenn.	25	14	14	28.0	14
Mississippi:					
Natchez, Miss.	46	(2)	2	46.9	1
Baton Rouge, La.	35	(2)	12	42.2	1
Donaldsonville, La.	28	(2)	10	32.7	1
New Orleans, La.	18	(2)	4	19.2	1
Illinois:					
Peru, Ill.	14	(2)	1	14.1	1
Henry, Ill.	7	(2)	11	8.8	1
Beardstown, Ill.	12	(2)	12	13.4	1-2
Grand:					
Brunswick, Mo.	10	29	29	10.0	29
Yazoo:					
Yazoo City, Miss.	25	(2)	14	29.7	1
Atchafalaya:					
Simmesport, La.	41	(2)	12	48.1	1
Melville, La.	37	(2)	14	43.0	1

[1] Continued into July. [2] Continued from May.

Flood stages during June, 1922—Continued.

River and station.	Flood stage.	Above flood stages—dates.		Crest.	
		From—	To—	Stage.	Date.
MISSISSIPPI DRAINAGE—continued.					
North Platte:					
North Platte, Nebr.	4.8	2	3	4.8	2-3
Arkansas:					
Ralston, Okla.	4	27	27	4.1	27
WEST GULF DRAINAGE.					
Trinity:					
Dallas, Tex.	25	7	7	26.1	7
Trinidad, Tex.	28	11	14	30.6	12-13
Liberty, Tex.	25	(2)	7	27.6	1-2
Nueces:					
Cotulla, Tex.	15	16	17	15.8	16-17
Rio Grande:					
Del Rio, Tex.	....	....	....	32.3	18
Eagle Pass, Tex.	16	18	21	45.6	19
Laredo, Tex.	28	20	20	43.9	20
Rio Grande City, Tex.	15	12	14	23.5	13
Do.	15	16	24	29.5	22
Mission, Tex.	24	19	25	28.4	23
COLORADO DRAINAGE.					
Colorado:					
Topock, Ariz.	14	(2)	7	19.7	4
Do.	14	13	21	16.4	16
Parker, Ariz.	7	(2)	(1)	11.0	3-4
Yuma, Ariz.	25	2	11	27.4	10
Do.	25	18	23	25.2	20-21
Lees Ferry, Ariz.	12	(2)	(1)	22.1	2
Gunnison:					
Sapinero, Colo.	16	(2)	1	16.3	1
Do.	16	6	12	17.0	9
North Fork of Gunnison:					
Paonia, Colo.	8	(2)	30	9.0	1, 8
Green:					
Elgin, Utah	13	(2)	2	13.3	1
Do.	13	11	14	13.4	12
PACIFIC DRAINAGE.					
San Joaquin:					
Firebaugh, Calif.	12	3	17	13.4	10
Lathrop, Calif.	17	1	25	18.2	6-8
Kings:					
Piedra, Calif.	12	(2)	10	13.8	5
Do.	12	16	21	12.5	17, 20
Columbia:					
Marcus, Wash.	24	(2)	(1)	30.5	18-19
Wenatchee, Wash.	40	8	10	40.2	9
Do.	40	13	19	40.4	15-18
Vancouver, Wash.	15	(2)	(1)	23.4	11
Kootenai:					
Bonners Ferry, Idaho	26	6	8	26.7	7
Pend O'Reille:					
Newport, Wash.	16	5	27	18.9	15-17
Clearwater:					
Kamiah, Idaho	14	5	7	14.4	6
Willamette:					
Portland, Oreg.	15	(2)	(1)	22.4	11-12

[1] Continued into July. [2] Continued from May.

MEAN LAKE LEVELS DURING JUNE, 1922.

By UNITED STATES LAKE SURVEY.

[Detroit, Mich., July 5, 1922.]

The following data are reported in the "Notice to Mariners" of the above date:

Data.	Lakes.[1]			
	Superior.	Michigan and Huron.	Erie.	Ontario.
Mean level during June, 1922:	*Feet.*	*Feet.*	*Feet.*	*Feet.*
Above mean sea level at New York	602.20	580.51	572.91	246.75
Above or below—				
Mean stage of May, 1922	+0.26	+0.14	+0.17	+0.20
Mean stage of June, 1921	−0.23	−0.04	−0.11	+0.14
Average stage for June, last 10 years	−0.24	−0.40	−0.09	−0.19
Highest recorded June stage	−1.23	−3.06	−1.61	−1.88
Lowest recorded June stage	+0.96	+0.64	+1.34	+1.86
Average relation of the June level to:				
May level	....	+0.20	+0.20	+0.20
July level	....	−0.10	0.00	+0.19

[1] Lake St. Clair's level: In June, 575.46 feet.

EFFECT OF WEATHER ON CROPS AND FARMING OPERATIONS, JUNE, 1922.

By J. B. KINCER, Meteorologist.

June, 1922, was on the whole warmer than normal in all sections of the country, except in sections of the Southwest and Southeast, and rainfall was very unevenly distributed geographically. Temperatures were unseasonably low, however, in the central and southern Great Plains and southern Rocky Mountain districts during the first few days of the month, but thereafter they were generally about normal, or higher. Heavy rains occurred in the Southeastern States early in the month, while moderate to heavy amounts were received in the central Northern States during the middle portion, and at the same time excessive rains fell in the interior of the Northeast.

The principal winter-wheat belt experienced favorable growing weather early in the month, but thereafter it was too warm for best maturing of the crop in many interior States. Winter wheat matured rapidly and there was considerable complaint of premature ripening, especially in the western portion of the belt. It was much too dry for winter wheat in the western and northwestern sections of the country, especially in Washington and Oregon. The warm, dry weather in the interior valley States was very favorable for harvest, and the drying of grain in shock, and harvest was progressing rapidly at the close of the month well to the northern limit of the winter-wheat growing area.

Spring wheat made satisfactory progress under favorable weather conditions in most of the principal producing areas, especially in the north-central portion of the belt. Moisture was mostly sufficient in North Dakota and the crop was in excellent condition throughout the State, and while there was some lack of rain in parts of South Dakota the crop continued as a rule in satisfactory condition. Conditions were less satisfactory, however, in the more southeastern portion of the belt and the drought was damaging to spring wheat, where unirrigated, in many Rocky Mountain and far northwestern localities.

Oats headed short in interior valley States as a result of the warm, dry weather, and hot winds did some damage in the central-northern sections of the country. Conditions were more favorable, however, for oats and other spring-sown grains in the Northeast.

Warm weather in the interior of the country was generally favorable for corn, and the crop made good growth in most sections. Corn did not suffer seriously for moisture during the month, although large areas in the interior valley States were in need of additional moisture the latter part, and late corn needed rain rather badly in Texas and on the uplands of Oklahoma.

The first part of the month was too cool for cotton in the northwestern portion of the belt, and rainfall was heavy in many localities, especially in the eastern cotton-growing area where field work was hindered, with many complaints of grassy fields. During the middle and latter portions of the month, temperatures were mostly above normal with generally light to moderate precipitation. Substantial improvement in the crop was widespread, and cultivation made satisfactory progress in the Central and Eastern States under the improved soil conditions. Excellent progress in cotton was reported from some sections the latter part of the month, the most favorable indications coming from Texas and Arkansas. Near the close of the month, the condition of cotton was reported as poor to fair in central and eastern Oklahoma, but very good in the northern and western portions. It was fair to excellent in southern and western Texas but mostly poor to fair elsewhere in that State. The warm, dry weather had proven beneficial in Georgia where the crop was blooming and fruiting well although its general condition was only poor to fair. Plants were blooming freely in east-central and southern South Carolina but the soil continued too wet for best results in eastern North Carolina. The warm weather and mostly light rainfall were favorable for holding boll weevil in check in many sections, but in general they were numerous in most localities.

Grasses and minor crops were favorably affected by the weather in the central and eastern portions of the country but pastures and ranges were in need of moisture in the more Western States and rain was badly needed in the far Southwest. The weather was generally favorable for fruit, except that severe local storms the latter part of the week ending June 13, caused much damage to orchards in central New York, and at the same time heavy winds blew off much orchard fruit in portions of New Jersey.

CLIMATOLOGICAL TABLES.[1]

CONDENSED CLIMATOLOGICAL SUMMARY.

In the following table are given for the various sections of the climatological service of the Weather Bureau the monthly average temperature and total rainfall; the stations reporting the highest and lowest temperatures, with dates of occurrence; the stations reporting the greatest and least total precipitation; and other data as indicated by the several headings.

The mean temperature for each section, the highest and lowest temperatures, the average precipitation, and the greatest and least monthly amounts are found by using all trustworthy records available.

The mean departures from normal temperatures and precipitation are based only on records from stations that have 10 or more years of observations. Of course, the number of such records is smaller than the total number of stations.

Condensed climatological summary of temperature and precipitation by sections, June, 1922.

Section.	Temperature.		Temperature. Monthly extremes.						Precipitation.		Precipitation. Greatest monthly.		Precipitation. Least monthly.	
	Section average.	Departure from the normal.	Station.	Highest.	Date.	Station.	Lowest.	Date.	Secton average.	Departure from the normal.	Station.	Amount.	Station.	Amount
	°F.	°F.		°F.			°F.		In.	In.		In.		In.
Alabama	78.7	+0.6	Selma	102	15	Maple Grove	50	1	3.64	−0.54	Bridgeport	7.97	Tuskegee	T.
Alaska														
Arizona	77.4	+2.4	Buckeye	120	19	Spring Valley	17	13	0.62	+0.22	Miami	3.57	2 stations	0.00
Arkansas	78.6	+1.8	Bee Branch	104	14	Dutton	44	4	2.64	−1.44	Murfreesboro	6.35	Marshall	0.32
California	68.9	+0.6	Greenland Ranch	123	21	Squirrel Inn	25	9	0.23	−0.10	Tamarack	2.80	63 stations	0.00
Colorado	63.4	+2.7	Lamar	106	9	Dillon	12	1	0.87	−0.57	Burlington	4.20	2 stations	T.
Florida	80.1	+0.4	Bonifay	103	15	Homestead	60	3	6.29	−0.37	Fort Myers	15.11	Sand Key	0.54
Georgia	78.7	+0.5	Hazlehurst	104	14	Clayton	48	24	5.08	+0.45	Waycross	9.00	Washington	1.29
Hawaii	73.3	+0.2	2 stations	91	[2] 20	3 stations	51	[2] 6	1.58	−3.20	Waikane	9.98	13 stations	0.00
Idaho	64.4	+4.0	Weiser	107	26	2 stations	22	1	0.90	−0.34	Grandview R. S.	2.56	Geneva	T.
Illinois	73.9	+2.4	2 stations	101	[2] 14	Sycamore	38	1	1.49	−2.36	Mount Vernon	5.00	2 stations	0.12
Indiana	73.1	+1.4	2 stations	101	24	Huntington	40	23	1.93	−1.91	Jeffersonville	4.18	Kokomo	0.07
Iowa	72.2	+3.1	Inwood	104	23	2 stations	38	[2] 1	1.82	−2.56	Corning	7.19	Iowa City	0.28
Kansas	75.2	+2.3	Colby	105	23	Oketo	40	2	2.36	−1.87	Chanute	6.03	Burr Oak	0.33
Kentucky	75.4	+1.7	3 stations	100	[2] 15	Farmers	44	23	3.10	−1.08	Greenville	6.86	Vanceburg	0.35
Louisiana	80.4	+0.3	Jeanerette	102	15	Calhoun	55	[2] 3	5.61	+0.87	Schriever	10.35	Richland Plantation	2.37
Maryland-Delaware	72.9	+2.7	Keedysville, Md.	97	25	2 stations	38	[2] 2	5.14	+1.10	State Sanitorium, Md	9.35	Western Port, Md.	2.05
Michigan														
Minnesota	66.4	+2.6	2 stations	102	[2] 22	Grand Marais	34	[2] 11	3.00	−1.00	Taylors Falls	6.18	Morris	0.99
Mississippi	79.6	+0.9	Columbus	104	15	University	53	4	3.73	−0.59	Greenville	8.51	Columbus	1.12
Missouri	76.5	+3.1	Caruthersville	108	14	Bethany (2)	43	1	1.66	−2.89	Gano	3.57	Warrenton	0.18
Montana	63.2	+3.6	2 stations	101	[2] 20	Harlowton	24	1	2.19	−0.37	Biddle	7.54	Polson	0.12
Nebraska	72.2	+2.9	3 stations	105	[2] 22	3 stations	31	[2] 1	2.41	−1.35	Madison	7.98	Kowanda	0.20
Nevada	68.7	+3.6	Logandale	113	[2] 20	Rye Patch	27	23	0.53	+0.01	Mahoney ranger station.	2.40	4 stations	0.00
New England	65.5	+1.3	2 stations	96	9	2 stations	33	14	8.11	+4.95	Durham, N. H.	11.92	Eastport, Me.	2.45
New Jersey	71.1	+2.5	Asbury Park	95	11	Belle Plain	39	13	6.31	+2.52	Newark	11.50	Northfield	2.97
New Mexico	69.5	+1.2	Orogrande	108	[2] 8	Luna	24	2	1.46	−0.18	Diener	7.20	3 stations	0.00
New York	66.3	+1.5	Dansville	96	24	Bolivar	32	13	7.85	+4.26	Syracuse	15.92	Buffalo	3.38
North Carolina	74.8	+1.5	2 stations	98	[2] 12	3 stations	38	[2] 23	6.41	+1.40	Tarboro	12.74	Cullowhee	2.36
North Dakota	63.5	+0.7	Hettinger	108	23	Powers Lake	30	1	3.76	+0.26	Taylor	7.54	Howard	0.64
Ohio	70.9	+1.5	Delaware	98	21	2 stations	37	23	2.98	−0.76	Toboso	7.57	Mount Healthy	1.05
Oklahoma	77.8	+1.3	Mangum	106	[2] 26	Kenton	44	3	1.74	−2.29	Hugo	5.77	Arapaho	0.19
Oregon	63.9	+4.1	Umatilla	104	25	2 stations	24	[2] 15	0.79	−0.65	Butte Falls	3.27	3 stations	T.
Pennsylvania	69.5	+1.9	New Castle	96	24	West Bingham	30	13	5.11	+0.91	Forest City	12.46	Beaver Falls	1.78
Porto Rico														
South Carolina	78.2	+0.6	2 stations	101	[2] 11	Calhoun Falls	52	24	5.48	+0.58	Conway	11.76	Allendale	2.62
South Dakota	68.4	+3.0	Pollock	107	22	Deadwood	32	[2] 1	3.72	−0.33	Lemmon	7.60	Roslyn	0.76
Tennessee	75.8	+1.4	2 stations	101	[2] 14	Mountain City	38	23	4.12	−0.29	2 stations	7.60	Dover	1.19
Texas	79.5	−0.7	Lampasas	107	26	3 stations	48	[2] 1	3.55	+0.36	Angleton	15.05	El Paso	0.05
Utah	67.6	+4.0	St. George	109	19	Ibapah	24	1	0.43	−0.25	Winterquarters	2.02	9 stations	0.00
Virginia	73.3	+1.9	Woodstock (near)	100	25	Marion	43	23	5.12	+0.73	West Point	10.08	Lawrenceville	1.01
Washington	64.6	+4.6	Billingham	97	1	Paradise	30	5	0.20	−1.38	Mill Creek	1.50	12 stations	0.00
West Virginia	70.7	+1.8	2 stations	97	[2] 17	Cheat Bridge	33	23	4.66	+0.45	Glenville	7.95	Upper Tract	1.75
Wisconsin	66.1	+1.7	Grantsburg	98	23	Long Lake	30	25	4.34	+0.18	New London	10.11	Williams Bay	0.36
Wyoming	61.7	+3.2	Basin	105	22	Dome Lake	15	1	1.37	−0.31	Knowles	5.42	Ervay	T.

[1] For description of tables and charts, see REVIEW, January, 1921, p. 41.

[2] Other dates also.

TABLE 1.—*Climatological data for Weather Bureau stations, June, 1922.*

Districts and stations.	Elevation of instruments.			Pressure.			Temperature of the air.												Precipitation.			Wind.										
	Barometer above sea level.	Thermometer above ground.	Anemometer above ground.	Station, reduced to mean of 24 hours.	Sea level, reduced to mean of 24 hours.	Departure from normal.	Mean max.+mean min.÷2.	Departure from normal.	Maximum.	Date.	Mean maximum.	Minimum.	Date.	Mean minimum.	Greatest daily range.	Mean wet thermometer.	Mean temperature of the dew-point.	Mean relative humidity.	Total.	Departure from normal.	Days with 0.01 inch, or more.	Total movement.	Prevailing direction.	Maximum velocity: Miles per hour.	Maximum velocity: Direction.	Maximum velocity: Date.	Clear days.	Partly cloudy days.	Cloudy days.	Average cloudiness, tenths.	Total snowfall.	Snow, sleet, and ice on ground at end of month.
	Ft.	Ft.	Ft.	In.	In.	In.	°F.	°F.	°F		°F	°F.		°F	°F.	°F.	°F.	%	In.	In.		Miles.								0–10	In.	In.
New England.							65.1	+1.0										83	6.61	+3.5										6.6		
Eastport	76	67	85	29.89	29.97	+.04	54.8	+0.4	82	5	63	41	15	46	31	53	51	89	2.45	−0.8	13	5,779	s.	33	sw.	1	4	10	16	7.3	0.0	0.0
Greenville, Me	1,070	6	....	28.80	29.96	.....	61.1	.....	86	8	70	39	14	52	31	....	....	....	10.00	.....	20	.....	....	....	....	....	9	5	16	....	0.0	0.0
Portland, Me	103	82	117	29.86	29.98	+.03	63.0	+0.5	91	8	70	49	14	56	28	58	55	80	10.47	+7.1	17	6,254	s.	42	se.	11	7	10	13	6.5	0.0	0.0
Concord	288	70	79	29.64	29.94	−.02	66.1	+1.7	91	8	76	45	14	56	33	....	....	....	7.88	+4.5	17	3,361	se.	32	nw.	12	8	10	12	6.4	0.0	0.0
Burlington	404	11	48	29.48	29.91	−.05	65.0	+1.2	87	8	73	45	14	57	26	....	....	....	9.92	+6.7	21	6,208	s.	40	nw.	12	3	13	14	6.9	0.0	0.0
Northfield	876	12	60	29.02	29.95	−.01	62.8	+0.1	86	8	73	38	14	53	38	60	58	88	7.88	+4.6	22	4,603	s.	30	sw.	11	1	14	15	7.5	0.0	0.0
Boston	125	115	188	29.83	29.96	.00	68.6	+2.1	92	9	76	52	13	62	30	63	60	77	8.05	+5.0	10	6,749	sw.	39	w.	12	6	10	14	6.5	0.0	0.0
Nantucket	12	14	90	29.98	29.99	+.01	64.4	+3.1	81	30	71	51	15	58	20	61	59	89	2.61	+0.2	7	10,707	sw.	43	sw.	11	10	7	13	5.9	0.0	0.0
Block Island	26	11	46	29.94	29.97	.00	64.8	+3.2	81	30	70	54	14	59	18	62	61	93	2.68	−0.2	12	10,479	sw.	46	sw.	11	8	9	13	6.0	0.0	0.0
Providence	160	215	251	29.79	29.96	−.01	68.6	+0.3	91	8	77	51	13	60	29	63	59	74	6.58	+3.4	13	7,977	s.	61	nw.	12	6	10	14	6.4	0.0	0.0
Hartford	159	122	140	29.79	29.96	−.01	69.2	+2.1	90	9	78	52	14	61	27	64	61	80	6.92	+3.8	13	5,251	s.	35	sw.	25	6	8	16	7.4	0.0	0.0
New Haven	106	74	153	29.85	29.96	−.01	69.0	+2.4	90	9	77	52	13	61	26	63	60	76	7.32	+4.2	17	5,826	s.	32	w.	12	8	8	14	6.3	0.0	0.0
Middle Atlantic States.							71.9	+1.6										76	5.86	+2.2										6.1		
Albany	97	102	115	29.84	29.94	−.03	69.2	+1.3	89	8	78	48	13	60	27	66	61	78	7.60	+3.8	16	4,903	s.	34	s.	17	9	12	9	5.8	0.0	0.0
Binghamton	871	10	84	29.04	29.95	−.02	67.0	+0.8	87	8	77	44	13	57	36	....	....	....	5.87	+2.3	15	3,279	w.	29	n.	6	4	11	15	6.9	0.0	0.0
New York	314	414	454	29.64	29.96	−.02	70.6	+2.1	87	7	77	53	13	64	24	64	61	76	7.86	+4.6	16	9,423	s.	75	nw.	11	3	12	15	6.7	0.0	0.0
Harrisburg	374	94	104	29.59	29.98	−.01	72.2	+1.9	89	24	81	54	13	64	32	64	60	69	2.91	−0.6	13	4,084	s.	27	sw.	11	2	12	16	7.0	0.0	0.0
Philadelphia	117	123	190	29.85	29.97	−.01	73.6	+2.4	90	11	81	56	13	66	22	66	62	70	4.56	+1.3	14	6,165	nw.	32	nw.	11	2	16	12	6.8	0.0	0.0
Reading	325	81	98	29.62	29.96	.....	72.0	.....	89	24	81	52	13	63	32	....	61	72	7.23	+3.6	17	3,413	se.	30	nw.	11	8	12	10	5.7	0.0	0.0
Scranton	805	111	119	29.13	29.98	.00	68.7	+1.5	88	8	78	48	13	59	36	63	61	78	7.06	+3.5	15	4,375	sw.	37	w.	12	3	12	15	6.8	0.0	0.0
Atlantic City	52	37	172	29.92	29.97	−.01	69.9	+3.3	90	11	75	54	13	64	22	66	63	83	5.46	+2.4	15	11,351	s.	45	s.	17	9	11	10	5.5	0.0	0.0
Cape May	18	13	49	29.99	30.01	+.03	70.7	+3.0	92	11	77	55	15	64	24	65	63	84	5.15	+2.1	18	4,818	s.	29	nw.	11	10	7	13	6.0	0.0	0.0
Sandy Hook	22	10	55	29.94	29.96	.....	70.2	.....	88	8	76	56	13	64	22	65	63	82	8.98	.....	16	8,587	s.	50	w.	11	6	14	10	5.9	0.0	0.0
Trenton	190	159	183	29.76	29.96	.....	71.8	.....	89	11	81	52	13	63	26	66	62	76	4.98	+1.5	16	7,102	w.	46	nw.	21	5	11	14	6.6	0.0	0.0
Baltimore	123	100	113	29.84	29.97	−.02	75.1	+2.1	93	25	83	59	13	67	23	68	64	73	4.45	+0.6	13	4,174	s.	23	sw.	11	7	10	13	6.2	0.0	0.0
Washington	112	62	85	29.85	29.97	−.03	74.5	+2.3	93	25	83	55	13	66	29	67	64	72	4.10	−0.1	12	4,155	sw.	33	nw.	11	8	13	9	5.9	0.0	0.0
Lynchburg	681	153	188	29.26	29.99	−.02	74.8	+0.2	93	30	85	55	24	65	35	67	63	71	3.37	−0.5	16	4,520	w.	35	sw.	30	10	10	10	5.6	0.0	0.0
Norfolk	91	170	205	29.90	30.00	.00	75.9	+1.5	91	30	84	60	14	68	23	69	66	79	9.78	+5.4	13	7,660	s.	40	n.	8	10	5	15	5.9	0.0	0.0
Richmond	144	11	52	29.84	29.99	−.02	75.0	−0.1	91	11	84	57	15	66	27	68	66	78	6.42	+2.9	17	4,784	sw.	31	nw.	17	11	5	14	5.4	0.0	0.0
Wytheville	2,304	49	56	27.69	29.99	−.02	69.1	+0.4	86	30	79	47	23	59	34	64	61	80	7.00	+2.9	15	3,367	w.	25	nw.	4	9	12	9	5.3	0.0	0.0
South Atlantic States.							77.7	+1.4										78	5.32	+0.4										5.4		
Asheville	2,255	70	84	27.73	30.01	.00	71.2	+2.5	87	16	81	52	24	61	32	64	61	78	3.68	−0.7	15	3,956	nw.	25	n.	20	6	19	5	5.2	0.0	0.0
Charlotte	779	55	62	29.18	30.00	−.01	77.6	+2.1	95	30	88	59	24	68	27	69	65	73	2.74	−1.7	14	2,847	se.	19	w.	9	2	15	7	5.5	0.0	0.0
Hatteras	11	12	11	29.99	30.00	−.01	75.4	+1.0	89	12	80	66	1	71	14	72	70	84	8.70	+4.4	16	8,734	s.	34	w.	10	6	11	13	6.2	0.0	0.0
Manteo	12	5	42	....	....	.....	74.0	.....	94	11	83	58	24	65	30	....	....	....	6.46	.....	12	.....	sw.	....	....	....	15	2	13	....	0.0	0.0
Raleigh	376	103	110	29.60	29.99	−.02	76.8	+1.7	93	12	86	61	23	68	24	69	66	76	5.91	+1.2	16	4,938	sw.	27	nw.	9	9	13	8	5.3	0.0	0.0
Wilmington	78	81	91	29.94	30.02	+.01	77.2	+1.7	94	12	84	64	16	70	22	72	70	83	7.67	+2.0	19	5,156	sw.	36	se.	29	8	12	10	5.6	0.0	0.0
Charleston	48	11	92	29.96	30.02	+.02	79.8	+0.9	97	12	86	69	26	74	21	73	71	77	3.54	−1.8	15	6,870	s.	30	s.	1	7	18	5	5.1	0.0	0.0
Columbia, S. C.	351	41	57	29.64	30.01	.00	79.0	+0.8	95	18	89	65	24	69	24	70	68	77	4.96	+0.8	12	4,811	s.	27	w.	14	7	13	10	5.4	0.0	0.0
Due West	711	10	55	29.27	30.03	.....	77.5	.....	93	30	88	61	24	67	25	....	....	....	3.02	.....	9	4,892	sw.	38	ne.	14	6	17	7	5.6	0.0	0.0
Greenville, S. C.	1,039	113	122	28.92	29.99	.....	76.4	.....	92	12	86	60	24	67	26	68	65	73	6.59	.....	12	4,775	w.	46	w.	12	9	15	6	4.9	0.0	0.0
Augusta	180	62	77	29.81	30.00	−.01	80.2	+1.5	96	12	90	63	24	70	26	72	70	75	4.28	−0.2	12	3,166	s.	34	e.	18	7	16	7	5.5	0.0	0.0
Savannah	65	150	194	29.95	30.02	+.02	80.2	+2.0	95	12	89	66	1	72	25	74	72	82	5.85	−0.2	10	6,808	s.	48	w.	20	10	10	10	5.2	0.0	0.0
Jacksonville	43	209	245	29.97	30.02	+.01	80.0	+0.1	93	13	88	65	23	72	22	73	71	81	5.88	+0.4	13	6,950	s.	42	nw.	23	9	17	4	4.9	0.0	0.0
Florida Peninsula.							80.9	+0.1										76	3.56	−3.3										5.4		
Key West	22	10	64	29.99	30.01	+.02	82.2	+0.3	91	21	87	69	25	77	20	75	72	73	3.78	−0.5	13	5,306	se.	29	sw.	1	11	16	3	4.6	0.0	0.0
Miami	25	71	79	30.01	30.04	.....	79.5	−0.9	89	20	85	69	21	74	17	74	72	76	4.50	−3.4	15	4,429	se.	30	nw.	20	5	15	10	6.3	0.0	0.0
Sand Key	23	39	72	30.00	30.04	+.05	81.1	.....	89	20	84	71	9	78	12	75	72	75	0.54	.....	6	6,489	se.	33	s.	1	8	18	4	4.6	0.0	0.0
Tampa	35	79	92	29.99	30.02	+.01	81.0	+1.0	93	17	89	67	25	73	23	74	72	79	2.41	−5.9	14	4,338	ne.	27	ne.	25	6	16	8	6.1	0.0	0.0
East Gulf States.							79.2	+1.1										77	4.00	−0.6										5.6		
Atlanta	1,174	190	216	28.81	30.02	+.02	76.8	+0.8	93	17	86	64	5	68	22	68	65	72	4.41	+0.5	10	5,820	nw.	60	nw.	18	7	8	15	6.1	0.0	0.0
Macon	370	78	87	29.62	30.01	.00	79.2	+2.1	96	14	89	64	24	70	25	71	68	72	5.46	+1.9	11	3,508	s.	29	nw.	4	7	14	9	5.5	0.0	0.0
Thomasville	273	49	58	29.72	30.01	+.01	80.0	+0.5	99	14	90	67	1	70	28	73	70	76	5.36	+0.6	11	2,389	sw.	16	nw.	21	3	16	11	6.6	0.0	0.0
Pensacola	56	149	185	29.95	30.01	+.02	79.5	+0.2	94	15	85	67	2	74	16	74	73	81	1.74	−3.1	9	7,049	s.	30	nw.	13	6	13	11	5.5	0.0	0.0
Anniston	741	9	57	29.25	30.03	+.03	76.7	+1.7	94	26	88	58	25	66	34	....	....	....	5.49	+1.6	9	2,413	sw.	22	nw.	20	7	21	2	4.6	0.0	0.0
Birmingham	700	11	48	29.28	30.03	+.04	78.1	−0.1	96	15	88	64	2	69	26	70	67	76	3.82	−0.1	11	3,179	s.	24	nw.	18	7	14	9	5.6	0.0	0.0
Mobile	57	125	161	29.94	30.00	+.01	80.8	+1.7	99	14	89	66	2	73	21	74	72	81	2.03	−3.9	13	5,224	w.	29	n.	28	9	15	6	5.4	0.0	0.0
Montgomery	223	100	112	29.77	30.02	+.02	80.6	+1.0	98	14	90	65	2	71	25	72	68	72	1.21	−3.0	8	3,566	sw.	22	n.	17	6	16	8	5.5	0.0	0.0
Corinth	469	6	....	....	....	.....	....	.....	....	....	....	....	....	....	....	....	....	....	....	.....	....	.....	....	....	....	....	....	....	....	....	....	....
Meridian	375	85	93	29.62	30.00	+.03	78.6	+1.3	97	16	88	63	3	69	25	71	69	77	4.45	−0.2	13	2,891	w.	31	se.	17	11	11	8	5.2	0.0	0.0
Vicksburg	247	65	73	29.74	30.02	+.05	79.2	+0.2	95	15	87	66	4	71	23	73	72	83	3.55	−0.9	13	3,426	se.	28	nw.	18	11	10	9	5.4	0.0	0.0
New Orleans	53	76	84	29.94	29.99	+.01	81.8	+2.2	96	24	88	70	1	75	21	75	72	77	6.45	+0.3	15	3,356	se.	19	sw.	28	7	17	6	5.7	0.0	0.0
West Gulf States.							79.8	+0.8										74	3.50	−0.1										4.9		
Shreveport	249	77	93	29.73	29.99	+.03	80.8	+1.2	97	17	90	64	4	72	24	73	70	76	3.77	+0.2	11	3,844	se.	40	nw.	2	18	8	4	3.9	0.0	0.0
Bentonville	1,303	11	44	....	....	.....	75.2	+1.1	95	24	86	50	3	64	30	....	....	....	2.48	.....	5	.....	....	....	....	....	16	9	5	....	0.0	0.0
Fort Smith	457	79	94	29.50	29.97	+.03	79.6	+2.8	99	24	90	58	4	70	28	71	67	68	1.04	−3.0	7	4,223	e.	30	nw.	26	10	12	8	5.2	0.0	0.0
Little Rock	357	136	144	29.61	29.98	+.02	79.4	+2.2	96	25	88	62	4	70	25	71	68	74	2.21	−1.9	7	4,577	s.	32	s.	6	11	8	11	5.3	0.0	0.0
Brownsville	57	4	26	....	....	.....	82.8	.....	96	3	92	69	1	74	26	....	....	....	5.55	.....	8	.....	se.	....	....	....					0.0	0.0
Corpus Christi	20	11	73	29.94	29.96	+.05	81.2	+0.6	91	21	87	71	6	75	19	75	73	78	3.68	+0.9	8	8,376	se.	37	nw.	3	12	10	8	4.9	0.0	0.0
Dallas	512	109	117	29.43	29.97	.....	80.2	.....	98	26	90	59	1	71	26	....	....	....	3.38	.....	6	5,315	s.	48	nw.	5	13	10	7	4.9	0.0	0.0
Fort Worth	670	106	114	29.24	29.94	+.02	80.2	+0.1	100	26	90	60	3	71	26	69	65	66	1.76	−1.2	6	5,860	se.	25	se.	7	11	12	7	4.9	0.0	0.0
Galveston	54	106	114	29.93	29.99	+.04	81.3	+0.6	91	25	86	67	7	76	18	75	73	78	8.96	+4.2	10	6,641	se.	32	se.	7	9	16	5	5.1	0.0	0.0
Groesbeck	461	11	56	29.49	29.96	.....	79.6	.....	95	26	89	62	1	70	24	....	....	....	5.42	.....	7	5,186	se.	29	sw.	19	12	9	9	4.8	0.0	0.0
Houston	138	111	121	29.82	29.96	.....	81.2	+0.2	97	25	89	66	2	73	23	....	....	....	5.51	.....	11	4,377	se.	34	se.	19	11	13	6	4.7	0.0	0.0
Palestine	510	64	72	29.45	29.97	+.03	79.6	+1.2	96	26	89	63	1	71	24	71	68	74	1.88	−2.1	8	3,973	s.	24	sw.	2	11	10	9	5.2	0.0	0.0
Port Arthur	34	58	66	29.94	29.98	.....	80.9	.....	93	25	88	67	7	74	19	75	72	80	8.46	.....	12	5,295	se.	28	nw.	19	13	10	7	4.5	0.0	0.0
San Antonio	701	119	132	29.24	29.95	+.05	79.4	−1.0	96	20	89	62	3	70	29	70	66	71	3.92	+0.8	10	4,287	s.	35	nw.	20	12	11	7	4.5	0.0	0.0
Taylor	582	55	63	29.38	29.99	+.07	79.8	−0.2	96	26	90	62	1	70	31	....	....	....	4.29	+0.8	8	4,636	se.	28	n.	19	10	11	9	5.3	0.0	0.0

TABLE I.—*Climatological data for Weather Bureau stations, April, 1922.*

Districts and stations.	Elevation of instruments.			Pressure.			Temperature of the air.										Mean wet thermometer.	Mean temperature of the dew-point.	Mean relative humidity.	Precipitation.			Wind.										
	Barometer above sea level.	Thermometer above ground.	Anemometer above ground.	Station, reduced to mean of 24 hours.	Sea level, reduced to mean of 24 hours.	Departure from normal.	Mean max.+mean min.÷2.	Departure from normal.	Maximum.	Date.	Mean maximum.	Minimum.	Date.	Mean minimum.	Greatest daily range.				Total.	Departure from normal.	Days with 0.01 inch, or more.	Total movement.	Prevailing direction.	Maximum velocity. Miles per hour.	Maximum velocity. Direction.	Maximum velocity. Date.	Clear days.	Partly cloudy days.	Cloudy days.	Average cloudiness, tenths.	Total snowfall.	Snow, sleet, and ice on ground at end of month.
Ohio Valley and Tennessee.	Ft.	Ft.	Ft.	In.	In.	In.	° F. 74.3	° F. +1.4	° F		° F	° F.		° F	° F.	° F.	° F.	% 71	In. 3.50	In. −0.7		Miles.								0–10 5.5	In.	In.
Chattanooga	762	189	213	29.22	30.01	+.01	76.1	+0.7	94	17	86	60	3	67	29	69	66	75	4.56	+0.2	17	3,962	w.	51	n.	12	5	19	6	5.8	0.0	0.0
Knoxville	996	102	111	28.98	30.01	+.01	75.8	+2.4	92	17	85	58	24	66	31	68	65	75	3.64	−0.5	17	3,763	sw.	22	sw.	13	3	9	18	6.9	0.0	0.0
Memphis	399	76	97	29.61	30.02	+.05	79.8	+2.2	96	16	88	62	3	72	24	71	67	69	3.31	−1.1	9	4,652	sw.	28	w.	11	11	5	14	5.3	0.0	0.0
Nashville	546	168	191	29.44	30.01	+.02	77.0	+1.4	95	16	86	59	5	68	29	69	66	73	5.37	+1.0	10	4,732	w.	28	s.	27	9	11	10	5.3	0.0	0.0
Lexington	989	193	230	28.96	30.00	.00	74.6	+1.4	91	17	84	60	13	66	25	......	......	......	2.44	−1.6	9	7,367	sw.	46	n.	11	10	7	13	5.2	0.0	0.0
Louisville	525	219	255	29.43	30.01	+.03	75.9	+1.2	93	17	85	58	13	67	30	67	63	68	4.00	−0.2	9	6,511	s.	59	nw.	13	9	16	5	4.8	0.0	0.0
Evansville	431	139	175	29.54	30.00	+.03	77.8	+2.5	96	16	88	57	1	68	28	68	64	69	2.65	−1.5	12	6,476	sw.	46	n.	13	6	20	4	5.3	0.0	0.0
Indianapolis	822	194	230	29.12	29.99	+.02	73.8	+1.4	93	16	84	51	1	64	26	64	59	63	0.99	−3.3	4	7,140	sw.	38	w.	28	10	15	5	4.8	0.0	0.0
Royal Center	736	11	55	29.20	29.98	......	70.2	......	97	24	83	47	4	58	42	......	......	......	0.87	......	5	6,020	sw.	32	w.	11	9	15	6	5.2	0.0	0.0
Terre Haute	575	96	129	29.35	29.96	......	75.0	......	96	16	86	54	1	64	35	65	59	62	3.67	......	4	6,007	sw.	42	nw.	30	6	19	5	5.1	0.0	0.0
Cincinnati	628	11	51	29.33	29.99	.00	73.7	+2.0	92	24	85	54	23	63	33	....	62	68	1.77	−2.2	9	4,311	sw.	32	nw.	28	11	13	6	5.0	0.0	0.0
Columbus	824	179	222	29.13	29.99	.00	71.6	+0.7	93	24	81	51	26	62	30	64	61	72	3.14	−0.4	9	6,411	n.	36	nw.	17	7	15	8	5.7	0.0	0.0
Dayton	899	181	216	29.02	29.96	......	72.8	+0.6	93	24	83	55	26	63	34	64	59	66	1.54	−2.4	7	6,295	ne.	36	nw.	27	12	12	6	4.4	0.0	0.0
Elkins	1,947	59	67	28.00	30.00	.00	67.8	+1.2	89	30	78	42	23	57	38	62	61	85	7.40	+2.4	14	2,797	nw.	25	nw.	11	3	12	15	7.0	0.0	0.0
Parkersburg	638	77	84	29.36	30.01	+.01	72.2	+0.7	92	17	82	49	23	62	34	65	62	75	5.06	+0.4	10	3,083	se.	36	nw.	11	9	8	13	6.1	0.0	0.0
Pittsburgh	842	353	410	29.10	29.98	−.01	71.2	+0.5	89	30	80	49	23	62	32	63	59	68	3.12	−0.8	13	6,445	nw.	39	w.	11	3	13	14	6.6	0.0	0.0
Lower Lake region.							**67.6**											**69**	**5.15**	**+1.6**										**5.3**		
Buffalo	767	247	280	29.15	29.97	.00	65.0	−0.1	85	28	72	47	13	58	24	60	56	76	3.38	+0.2	13	9,694	sw.	52	w.	11	8	8	14	6.3	0.0	0.0
Canton	448	10	61	29.43	29.90	......	64.6	−1.2	87	24	74	40	13	56	30	......	......	......	7.56	+4.1	18	5,949	sw.	39	sw.	29	10	12	8	5.2	0.0	0.0
Oswego	335	76	91	......	29.94	−.03	64.1	+0.3	88	24	71	49	13	57	27	......	......	......	5.89	+2.5	15	5,661	w.	29	w.	12	8	12	10	....	0.0	0.0
Rochester	523	86	102	29.41	29.97	.00	66.8	+0.7	92	24	76	47	13	58	27	60	55	70	8.14	+5.0	15	5,425	sw.	32	nw.	12	8	10	12	6.0	0.0	0.0
Syracuse	597	97	113	29.32	29.96	−.01	66.4	−0.5	86	24	74	45	13	58	27	......	......	......	15.92	+12.0	14	6,383	nw.	48	w.	12	6	11	13	6.4	0.0	0.0
Erie	714	130	166	29.22	29.97	−.01	67.7	+0.7	90	24	75	48	13	60	26	61	56	68	2.11	−1.6	11	7,928	n.	43	w.	17	11	14	5	4.8	0.0	0.0
Cleveland	762	190	201	29.18	29.99	+.01	68.6	+1.5	92	24	76	53	1	61	27	61	56	68	2.66	−1.0	11	7,493	ne.	36	sw.	16	11	11	8	5.4	0.0	0.0
Sandusky	629	62	103	29.31	29.99	+.01	70.0	+1.2	94	24	78	52	26	62	31	......	......	......	1.96	−1.9	9	7,353	sw.	42	sw.	16	8	15	7	5.0	0.0	0.0
Toledo	628	208	243	29.32	29.99	+.02	69.9	+1.2	94	24	79	52	1	61	27	62	58	69	2.43	−1.0	12	8,413	sw.	43	sw.	11	12	15	3	4.5	0.0	0.0
Fort Wayne	856	113	124	29.08	29.99	......	70.8	+2.3	95	24	81	52	4	61	31	62	57	65	1.85	......	7	5,558	sw.	27	sw.	9	8	16	6	5.0	0.0	0.0
Detroit	730	218	245	29.21	29.99	+.02	69.2	+1.8	94	24	78	48	26	60	26	61	57	66	1.46	−2.4	9	6,957	sw.	36	sw.	17	10	16	4	4.6	0.0	0.0
Upper Lake region.							**64.3**	**+1.7**										**71**	**2.97**	**−0.4**										**4.9**		
Alpena	609	13	92	29.32	29.98	+.02	62.2	+2.9	92	7	72	39	26	52	40	57	52	71	2.51	−1.0	7	6,847	se.	38	e.	16	11	12	7	4.8	0.0	0.0
Escanaba	612	54	60	29.31	29.96	+.02	61.1	+0.5	85	14	70	38	25	53	40	56	52	75	3.63	0.0	8	6,767	s.	36	n.	24	13	9	8	4.5	0.0	0.0
Grand Haven	632	54	89	29.30	29.97	+.01	65.0	+0.3	84	16	74	43	1	56	27	59	55	71	1.85	−0.7	6	6,391	w.	34	sw.	10	17	8	5	4.0	0.0	0.0
Grand Rapids	707	70	87	29.23	29.98	+.01	69.6	+1.5	92	16	80	44	1	59	33	60	54	60	3.16	+0.6	7	3,504	w.	22	w.	16	12	10	8	5.0	0.0	0.0
Houghton	684	62	99	29.22	29.94	.00	60.8	+1.4	95	23	71	37	25	51	34	......	......	......	4.00	+0.5	12	7,226	e.	50	w.	24	9	12	9	5.5	0.0	0.0
Lansing	878	11	62	29.05	29.98	......	67.4	0.0	91	24	80	44	1	55	38	61	57	72	1.83	−1.6	9	3,031	sw.	20	s.	30	8	17	5	5.1	0.0	0.0
Ludington	637	60	66	29.29	29.98	......	62.2	......	83	16	70	42	1	54	22	57	54	75	3.77	......	8	5,808	s.	31	s.	23	18	10	2	3.6	0.0	0.0
Marquette	734	77	111	29.19	29.99	+.05	60.0	+1.5	94	23	70	38	25	50	41	54	49	71	4.50	+1.0	10	5,484	sw.	33	sw.	11	9	8	13	6.0	0.0	0.0
Port Huron	638	70	120	29.29	29.98	+.01	65.6	+1.8	95	24	75	46	26	56	36	60	57	76	1.92	−1.3	7	6,524	ne.	40	nw.	11	6	22	2	4.3	0.0	0.0
Saginaw	641	69	77	29.30	29.98	......	67.0	......	90	24	78	44	1	56	34	60	55	70	4.15	+1.5	8	4,856	sw.	31	nw.	16	11	12	7	5.2	0.0	0.0
Sault Ste. Marie	614	11	52	29.29	29.97	+.01	59.6	+2.0	90	7	71	36	26	48	34	54	51	74	2.60	−0.2	5	4,628	nw.	34	nw.	24	10	10	10	5.0	0.0	0.0
Chicago	823	140	310	29.12	29.99	+.03	70.8	+2.6	95	16	78	51	1	64	30	62	56	63	0.12	−3.5	4	7,408	n.	35	w.	10	13	13	4	3.9	0.0	0.0
Green Bay	617	109	144	29.30	29.96	+.01	66.6	+1.5	91	23	76	43	25	57	30	60	56	71	4.88	+1.3	11	6,982	s.	39	w.	16	4	15	11	6.4	0.0	0.0
Milwaukee	681	125	139	29.25	29.98	+.03	67.3	+3.8	94	23	76	47	1	59	33	59	54	64	2.48	−1.2	8	5,959	ne.	30	sw.	16	15	8	7	4.5	0.0	0.0
Duluth	1,133	11	47	28.74	29.95	+.03	59.9	+2.7	92	23	70	41	25	49	42	54	51	79	3.97	−0.6	15	7,819	ne.	52	w.	7	11	11	8	5.3	0.0	0.0
North Dakota.							**65.1**	**+1.8**										**68**	**3.24**	**−0.4**										**5.4**		
Moorhead	940	50	58	28.91	29.91	+.01	65.6	+1.3	94	22	76	46	1	55	35	59	55	69	2.93	−1.2	8	5,496	n.	27	nw.	23	7	8	15	6.1	0.0	0.0
Bismarck	1,674	8	57	28.19	29.94	+.07	66.2	+2.5	95	5	77	44	1	55	37	60	55	71	3.24	−0.3	12	5,736	e.	38	w.	23	15	9	6	4.3	0.0	0.0
Devils Lake	1,482	11	44	28.35	29.90	+.02	63.8	+1.2	94	5	75	43	9	53	34	57	52	69	2.52	−1.0	9	6,585	sw.	36	n.	16	12	10	8	4.8	0.0	0.0
Ellendale	1,457	10	56	28.37	29.91	......	64.2	......	90	22	75	44	1	53	37	......	......	......	2.71	......	10	8,409	sw.	51	w.	15	7	11	12	5.9	0.0	0.0
Grand Forks	835	12	89	......	......	......	64.4	......	92	5	76	45	25	53	35	......	......	......	1.81	......	11	......	......	......	......	......	13	10	7	....	0.0	0.0
Williston	1,878	41	48	27.95	29.89	+.03	64.7	+2.0	91	4	76	45	9	54	38	57	51	65	4.28	+0.7	11	5,546	ne.	56	w.	22	9	11	10	5.8	0.0	0.0
Upper Mississippi Valley.							**73.1**	**+2.3**										**64**	**2.02**	**−2.3**										**4.5**		
Minneapolis	918	102	208	28.95	29.91	......	69.4	......	99	23	79	50	1	60	29	......	......	......	5.63	+1.6	12	7,748	se.	54	n.	9	11	9	10	5.6	0.0	0.0
St. Paul	837	236	261	29.05	29.95	+.03	68.3	+1.2	97	23	78	49	1	58	27	......	......	......	4.61	+0.2	12	8,161	se.	56	w.	15	10	16	4	4.7	0.0	0.0
La Crosse	714	11	48	29.20	29.96	+.03	69.3	+1.1	93	23	80	44	1	59	31	......	......	......	3.30	−1.1	13	3,014	se.	16	n.	10	11	12	7	4.6	0.0	0.0
Madison	974	70	78	28.96	29.99	+.05	68.6	+1.3	91	23	78	48	1	60	29	61	57	69	3.17	−0.9	8	4,953	sw.	30	n.	10	10	11	9	5.2	0.0	0.0
Wausau	1,247	4	....	28.67	30.00	......	65.0	......	89	23	75	40	1	55	33	......	......	......	4.87	......	11	......	w.	......	......	......	13	4	13	5.3	0.0	0.0
Charles City	1,015	10	49	28.91	29.96	+.05	70.0	+1.2	95	23	81	43	1	59	33	63	58	66	1.00	−4.1	11	4,156	sw.	23	se.	15	13	14	3	4.2	0.0	0.0
Davenport	606	71	79	29.33	29.98	+.04	73.4	+2.5	95	23	84	47	1	63	29	65	59	63	1.22	−2.9	4	4,758	sw.	29	s.	10	14	12	4	3.8	0.0	0.0
Des Moines	861	84	97	29.06	29.95	+.03	74.0	+3.6	95	15	84	48	3	64	28	65	60	63	1.63	−3.3	7	4,767	sw.	32	sw.	15	15	12	3	4.0	0.0	0.0
Dubuque	698	81	96	29.26	29.99	+.06	71.2	+1.8	94	23	81	44	1	61	30	64	59	67	1.20	−3.4	9	3,900	s.	20	sw.	16	15	6	9	4.7	0.0	0.0
Keokuk	614	64	78	29.32	29.98	+.04	75.0	+2.5	96	23	85	51	3	65	29	65	59	58	1.08	−3.3	6	4,195	n.	34	nw.	13	14	12	4	4.4	0.0	0.0
Cairo	356	87	93	29.60	29.97	.00	78.3	+3.1	96	15	87	60	1	70	24	69	65	68	1.44	−2.9	13	4,831	n.	31	sw.	26	6	12	12	5.9	0.0	0.0
Peoria	609	11	45	29.33	29.99	+.04	73.2	+2.3	96	23	85	48	1	62	33	66	61	66	0.99	−3.3	4	3,453	ne	22	s.	10	22	6	2	2.6	0.0	0.0
Springfield	644	10	91	29.30	29.96	+.01	75.4	+3.2	98	24	87	52	3	64	32	65	60	62	1.19	−3.1	4	5,221	sw.	41	n.	13	14	12	4	3.9	0.0	0.0
Hannibal	534	74	109	29.42	29.98	+.03	76.0	+2.7	96	23	86	53	4	65	30	......	......	......	0.96	−2.6	7	5,096	sw.	37	nw.	13	13	14	3	4.1	0.0	0.0
St. Louis	567	265	303	29.37	29.96	+.01	78.2	+3.4	96	24	87	57	3	69	27	68	63	63	0.80	−3.7	7	7,177	s.	37	s.	10	8	17	5	5.0	0.0	0.0
Missouri Valley.							**74.0**	**+3.1**										**64**	**2.70**	**−1.6**										**3.9**		
Columbia, Mo.	781	11	84	29.15	29.96	+.01	75.6	+1.1	97	24	86	50	3	65	31	......	......	......	2.01	−2.4	8	4,040	s.	26	w.	30	12	11	7	4.6	0.0	0.0
Kansas City	963	161	181	28.95	29.95	+.03	77.2	+4.2	96	23	86	51	1	68	26	67	62	63	1.13	−3.5	9	6,311	sw.	45	ne.	25	19	9	2	3.3	0.0	0.0
St. Joseph	967	11	49	28.93	29.94	......	76.2	......	97	13	87	51	1	66	30	66	61	63	1.75	......	7	4,616	s.	44	nw.	28	22	7	1	2.6	0.0	0.0
Springfield, Mo.	1,324	98	104	28.61	29.99	+.04	75.7	+3.4	96	24	85	54	1	66	25	66	62	66	0.66	−4.5	3	5,441	s.	36	sw.	19	17	11	2	3.2	0.0	0.0
Iola	984	11	50	28.94	29.96	+.03	76.6	+3.2	96	25	88	50	3	65	31	......	......	......	5.63	+0.9	6	3,635	s.	28	sw.	30	13	16	1	4.3	0.0	0.0
Topeka	987	92	107	......	......	......	76.4	+2.9	95	13	87	48	2	66	30	......	......	......	1.35	−3.5	6	6,146	s.	50	n.	25	14	14	2	3.7	0.0	0.0
Drexel	1,299	10	54	28.58	29.94	......	73.3	......	97	23	85	49	3	62	32	......	......	......	2.70	......	11	6,681	s.	39	sw.	15	12	12	6	4.4	0.0	0.0
Lincoln	1,189	11	84	28.69	29.92	+.02	75.4	+3.8	100	23	88	48	3	63	33	65	59	61	2.37	−2.0	13	6,538	s.	42	nw.	8	11	16	3	4.2	0.0	0.0
Omaha	1,105	115	122	28.79	29.94	+.03	75.6	+4.0	98	23	86	52	3	65	32	65	60	61	2.68	−2.4	9	4,680	s.	54	nw.	12	16	10	4	3.5	0.0	0.0
Valentine	2,598	47	54	27.26	29.93	+.07	69.6	+2.4	102	22	82	42	2	57	40	60	54	63	4.03	+0.2	9	6,364	e.	47	nw.	14	16	10	4	3.6	0.0	0.0
Sioux City	1,135	94	164	28.75	29.93	+.03	73.0	+3.6	98	23	84	45	3	62	34	63	56	58	2.03	−1.8	7	7,620	s.	67	s.	8	14	6	10	4.7	0.0	0.0
Huron	1,306	59	74	28.57	29.95	+.07	69.1	+2.9	99	22	81	44	1	57	38	62	57	66	3.24	−0.5	12	5,863	se.	40	w.	15	15	11	4	3.2	0.0	0.0
Pierre	1,572	70	75	28.28	29.91	+.04	70.5	+2.0	101	22	81	46	2	60	36	63	59	71	4.60	+1.5	12	5,621	se.	38	w.	14	14	10	6	4.1	0.0	0.0
Yankton	1,233	49	57	28.63	29.91	+.02	73.0	+4.1	98	23	84	44	3	62	40	......	......	......	2.62	−1.6	9	5,123	sw.	24	s.	22	8	14	8	5.2	0.0	0.0

TABLE 1.—*Climatological data for Weather Bureau stations, April, 1922*—Continued.

Districts and stations.	Elevation of instruments: Barometer above sea level.	Elevation of instruments: Thermometer above ground.	Elevation of instruments: Anemometer above ground.	Pressure: Station, reduced to mean of 24 hours.	Pressure: Sea level, reduced to mean of 24 hours.	Pressure: Departure from normal.	Temperature of the air: Mean max.+mean min.÷2.	Temperature of the air: Departure from normal.	Temperature of the air: Maximum.	Temperature of the air: Date.	Temperature of the air: Mean maximum.	Temperature of the air: Minimum.	Temperature of the air: Date.	Temperature of the air: Mean minimum.	Temperature of the air: Greatest daily range.	Mean wet thermometer.	Mean temperature of the dew-point.	Mean relative humidity.	Precipitation: Total.	Precipitation: Departure from normal.	Precipitation: Days with .01 inch, or more.	Wind: Total movement.	Wind: Prevailing direction.	Wind: Maximum velocity: Miles per hour.	Wind: Maximum velocity: Direction.	Wind: Maximum velocity: Date.	Clear days.	Partly cloudy days.	Cloudy days.	Average cloudiness, tenths.	Total snowfall.	Snow, sleet, and ice on ground at end of month.
	Ft.	Ft	Ft.	In.	In.	In.	° F.	° F.	° F		° F	° F.		° F	° F.	° F.	° F.	%	In.	In.		Miles.								0–10	In.	In.
Northern Slope.							65.5	+3.6										57	1.20	−1.1										3.6		
Billings	3,140	5	.....	.....	.....	.....	67.6	.....	98	21	84	35	1	51	58	.....	.....	.....	2.40	.....	9	.....	.....	.....	.....	.....	18	6	6	.....	0.0	0.0
Havre	2,505	11	44	27.33	29.92	+.07	65.6	+3.6	97	21	79	40	1	52	41	55	48	61	0.82	−2.0	10	4,800	e.	42	n.	20	18	8	4	3.6	0.0	0.0
Helena	4,110	87	112	25.80	29.93	+.05	63.6	+3.0	92	20	77	40	1	50	37	52	44	58	2.58	+0.5	15	5,080	sw.	29	sw.	20	11	13	6	4.6	0.0	0.0
Kalispell	2,973	48	56	26.88	29.88	−.01	63.8	+5.0	92	20	78	39	10	50	42	51	40	51	0.54	−1.2	4	4,269	nw.	29	sw.	5	23	4	3	3.2	0.0	0.0
Miles City	2,371	26	48	27.44	29.94	+.09	69.6	+3.6	98	22	82	44	1	57	38	60	55	67	1.53	−1.2	9	4,157	se.	39	n.	22	13	12	5	4.1	0.0	0.0
Rapid City	3,259	50	58	26.61	29.96	+.11	67.7	+3.9	99	22	79	41	2	56	31	58	51	50	2.62	−1.0	12	5,235	w.	38	n.	17	13	13	4	4.2	0.0	0.0
Cheyenne	6,088	84	101	24.07	29.91	+.07	63.8	+2.3	93	22	78	29	1	50	39	51	42	53	0.90	−0.7	7	7,587	w.	39	sw.	9	13	17	0	3.5	0.5	0.0
Lander	5,372	60	68	24.67	29.90	+.05	65.2	+3.9	94	20	82	32	1	49	41	51	40	45	0.38	−0.7	3	3,794	sw.	38	w.	22	20	9	1	3.1	0.0	0.0
Sheridan	3,790	10	47	26.11	29.94	.....	64.6	.....	99	21	79	31	1	50	46	56	49	62	2.21	.....	13	3,489	nw.	33	nw.	22	17	10	3	3.4	0.0	0.0
Yellowstone Park	6,200	11	48	23.94	29.94	+.08	57.8	+1.8	86	20	73	29	1	42	40	46	36	52	0.56	−1.1	8	5,047	sw.	35	s.	22	15	11	4	3.8	0.0	0.0
North Platte	2,821	11	51	27.08	29.95	+.09	72.8	+5.3	99	22	86	46	2	59	36	62	56	62	0.87	−2.4	5	4,682	s.	25	ne.	25	23	6	1	2.1	0.0	0.0
Middle Slope.							74.4	+2.6										59	1.41	−1.8										4.1		
Denver	5,292	106	113	24.77	29.90	+.06	70.4	+4.1	98	21	84	37	1	57	37	54	42	44	0.19	−1.3	4	5,569	s.	32	se.	12	13	15	2	4.2	0.0	0.0
Pueblo	4,685	80	86	25.31	29.90	+.07	71.8	+2.8	98	9	87	43	3	57	38	56	48	52	0.53	−0.9	7	4,568	n.	36	nw	27	9	20	1	4.5	0.0	0.0
Concordia	1,392	50	58	28.50	29.93	+.03	76.0	+3.3	97	23	88	47	2	64	32	65	59	59	2.10	−2.9	7	5,516	s.	30	ne.	25	13	16	1	4.0	0.0	0.0
Dodge City	2,509	11	51	27.41	29.96	+.09	74.5	+1.4	96	10	87	50	1	62	30	64	59	65	1.37	−2.0	6	6,672	s.	28	s.	9	24	5	1	2.2	0.0	0.0
Wichita	1,358	139	158	28.53	29.93	+.02	76.1	+1.8	96	24	86	52	2	66	33	67	62	67	3.99	−0.8	8	7,992	s.	66	nw.	24	14	13	3	3.9	0.0	0.0
Altus	1,410	5	.....	.....	.....	.....	80.1	.....	103	29	93	57	1	67	33	.....	.....	.....	2.22	.....	6	.....	.....	.....	.....	.....	14	6	10	.....	0.0	0.0
Broken Arrow	765	11	52	29.17	29.99	.....	76.9	.....	95	24	87	54	3	67	24	.....	.....	.....	1.01	.....	3	6,911	s.	32	nw.	26	8	17	5	5.2	0.0	0.0
Muskogee	652	4	.....	.....	.....	.....	79.0	.....	101	24	91	54	3	67	33	.....	.....	.....	0.97	.....	5	.....	w.	.....	.....	.....	18	5	7	.....	0.0	0.0
Oklahoma City	1,214	10	47	28.72	29.96	+.05	77.9	+2.2	99	29	88	55	1	68	26	60	64	68	0.30	−2.8	5	6,180	s.	26	s.	10	10	15	5	4.9	0.0	0.0
Southern Slope.							76.5	−0.7										62	2.98	+0.3										4.2		
Abilene	1,738	10	52	28.17	29.93	+.05	78.0	−0.2	99	26	89	57	4	67	30	67	62	62	1.80	−1.4	4	5,628	s.	28	nw.	2	15	9	6	4.5	0.0	0.0
Amarillo	3,676	10	49	26.29	29.95	+.10	73.4	+1.4	94	27	85	49	1	62	31	63	58	67	3.77	+0.8	6	7,652	s.	37	n.	1	18	11	1	3.4	0.0	0.0
Del Rio	944	64	71	28.96	29.92	+.07	79.7	−2.4	94	20	89	58	3	71	25	.....	.....	.....	4.67	+2.2	8	6,859	se.	42	n.	5	12	11	7	4.8	0.0	0.0
Roswell	3,566	75	85	26.35	29.88	+.08	74.8	−1.5	97	30	88	50	1	62	35	62	54	56	1.69	−0.4	6	5,949	s.	42	ne.	1	13	12	5	4.1	0.0	0.0
Southern Plateau.							78.8	+1.2										35	0.18	−0.2										2.0		
El Paso	3,762	110	133	26.14	29.78	+.03	81.4	+1.8	104	9	94	60	1	69	35	60	44	36	0.05	−0.5	2	7,824	e.	48	sw.	27	23	7	0	1.9	0.0	0.0
Santa Fe	7,013	38	53	23.33	29.84	+.03	66.4	+0.2	87	9	80	39	3	52	36	50	38	41	0.74	−0.3	5	4,201	se.	26	ne.	21	16	14	0	3.3	0.0	0.0
Flagstaff	6,908	10	59	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Phoenix	1,108	76	81	28.63	29.74	.00	86.2	+1.8	114	19	103	56	14	69	46	62	45	30	T.	−0.1	0	3,812	e.	32	se.	24	22	6	2	1.8	0.0	0.0
Yuma	141	9	54	29.61	29.75	+.01	86.5	+1.8	115	18	103	58	11	70	45	66	54	40	0.09	+0.1	1	3,588	sw.	23	se.	22	25	4	1	1.5	0.0	0.0
Independence	3,957	9	41	25.92	29.88	+.10	73.6	+0.2	100	25	90	47	12	57	44	52	33	28	T.	−0.1	0	4,086	se.	28	sw.	1	25	5	0	1.7	0.0	0.0
Middle Plateau.							69.3	+3.8										35	0.38	−0.1										2.8		
Reno	4,532	74	81	25.47	29.90	+.04	66.2	+5.2	99	25	82	39	10	50	47	40	36	43	0.92	+0.7	2	5,322	w.	42	w.	13	20	8	2	2.5	0.0	0.0
Tonopah	6,090	12	20	24.09	29.88	.....	69.1	.....	94	25	82	42	14	56	33	49	32	31	0.04	−0.4	2	5,736	se.	33	se.	12	17	13	0	3.1	0.0	0.0
Winnemucca	4,344	18	56	25.59	29.91	+.03	67.4	+4.1	99	25	84	41	10	51	46	50	35	39	0.15	−0.5	3	4,866	sw.	32	se.	4	20	8	2	2.4	0.0	0.0
Modena	5,479	10	43	24.62	29.87	+.05	65.7	+2.5	94	19	84	34	11	47	45	47	29	32	0.23	−0.2	4	8,543	sw.	46	sw.	13	18	11	1	2.7	0.0	0.0
Salt Lake City	4,360	163	203	25.60	29.87	+.02	73.0	+5.6	97	21	85	51	14	61	35	54	39	34	0.83	+0.1	4	5,571	nw.	42	sw.	13	23	4	3	2.4	0.0	0.0
Grand Junction	4,602	60	68	25.36	29.87	+.04	74.2	+1.6	100	21	89	44	1	59	39	54	39	32	0.09	−0.3	3	4,426	se.	38	se.	22	13	14	3	4.0	0.0	0.0
Northern Plateau.							69.6	+4.8										45	0.58	−0.6										3.0		
Baker	3,471	48	53	26.43	29.96	+.01	63.3	+4.7	91	25	79	40	23	48	47	51	42	54	0.61	−0.6	5	4,242	se.	30	sw	16	17	9	4	3.1	0.0	0.0
Boise	2,739	78	86	27.11	29.91	.00	70.3	+4.3	99	25	85	47	23	56	38	55	42	44	0.57	−0.3	5	3,306	nw.	26	w.	8	23	3	4	2.2	0.0	0.0
Lewiston	757	40	48	29.12	29.91	−.03	73.0	+3.9	100	25	89	48	1	57	45	.....	.....	.....	0.96	−0.1	4	2,454	ne.	26	s.	4	18	6	6	3.3	0.0	0.0
Pocatello	4,477	60	68	25.46	29.89	+.02	67.3	+3.1	94	26	82	42	1	52	41	51	37	41	0.82	−0.2	6	5,103	se.	36	sw.	13	17	10	3	3.2	0.0	0.0
Spokane	1,929	101	110	27.90	29.90	−.04	69.8	+6.4	93	26	84	49	1	56	39	54	41	42	0.02	−1.6	2	4,101	sw.	28	n.	8	15	10	5	3.6	0.0	0.0
Walla Walla	991	57	65	28.86	29.91	−.05	73.9	+5.7	100	25	87	53	23	61	39	58	47	42	0.51	−0.7	3	3,547	sw.	26	sw.	4	22	7	1	2.4	0.0	0.0
North Pacific Coast region.							60.5	+1.8										73	0.26	−1.7										5.1		
North Head	211	11	56	29.84	30.07	+.08	54.8	−0.2	62	18	58	48	17	52	13	52	50	85	0.35	−1.4	3	11,061	nw.	43	n.	16	6	15	9	5.8	0.0	0.0
Port Angeles	29	8	53	30.05	30.08	.....	55.1	.....	71	19	24	43	17	62	48	.....	.....	.....	0.19	−1.1	2	5,177	sw.	24	w.	16	20	6	4	3.5	0.0	0.0
Seattle	125	215	250	29.93	30.06	+.06	60.8	+0.7	81	25	70	49	17	52	28	53	47	66	0.03	−1.5	2	5,392	n.	25	sw.	20	10	10	10	5.0	0.0	0.0
Tacoma	213	113	120	29.84	30.06	+.03	61.4	+2.0	82	26	71	48	6	52	28	.....	.....	.....	0.02	−2.1	1	4,224	n.	17	n.	23	5	16	9	6.3	0.0	0.0
Tatoosh Island	86	7	57	29.97	30.07	+.05	53.6	+0.6	66	19	57	48	17	50	17	51	49	80	0.11	−4.1	4	7,326	sw.	34	s.	20	3	8	19	7.7	0.0	0.0
Yakima	1,071	5	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Medford	1,425	4	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Portland, Oreg.	153	68	196	29.86	30.02	−.02	65.5	+3.1	89	19	76	46	15	55	30	56	50	61	0.14	−1.6	4	4,237	nw.	18	n.	17	11	10	7	5.0	0.0	0.0
Roseburg	510	9	57	29.47	30.02	−.01	67.0	+4.5	97	25	82	45	15	52	42	56	49	62	1.01	−0.1	2	2,460	n.	15	sw.	7	21	8	1	2.4	0.0	0.0
Middle Pacific Coast region.							63.8	+1.5										66	0.08	−0.3										4.0		
Eureka	62	73	89	29.98	30.05	.00	55.6	+1.0	65	21	60	46	6	51	15	52	50	85	0.14	−0.9	5	4,165	n.	25	n.	22	9	11	10	5.5	0.0	0.0
Point Reyes	490	7	18	29.44	29.96	.....	53.6	+0.8	68	17	58	46	1	49	20	.....	.....	.....	0.07	.....	3	12,061	nw.	54	nw.	22	4	4	22	7.8	0.0	0.0
Red Bluff	332	50	56	29.54	29.88	.00	76.6	+1.8	110	25	91	54	3	62	40	60	48	45	0.01	−0.4	1	3,713	se.	20	s.	20	25	4	1	1.7	0.0	0.0
Sacramento	69	106	117	29.84	29.90	+.01	71.0	+1.6	105	25	85	50	6	57	39	58	49	53	T.	−0.2	0	6,373	s.	24	s.	1	23	6	1	2.0	0.0	0.0
San Francisco	155	208	243	29.80	29.98	+.02	60.0	+3.0	84	17	67	50	21	53	31	54	51	81	0.26	+0.1	2	7,200	w.	32	w.	1	16	11	3	3.8	0.0	0.0
San Jose	141	12	110	29.81	29.96	.....	65.7	+0.7	98	17	79	45	3	52	45	.....	.....	.....	0.01	−0.1	1	4,260	nw.	21	n.	21	17	12	1	3.0	0.0	0.0
South Pacific Coast region.							68.1	+1.4										66	0.03	0.0										2.8		
Fresno	327	89	98	29.54	29.89	+.04	76.5	+0.7	109	25	91	52	14	62	39	58	44	40	0.12	0.0	1	6,538	nw.	30	nw.	8	26	3	1	1.1	0.0	0.0
Los Angeles	338	159	191	29.56	29.92	+.02	67.7	+1.0	90	19	78	54	12	58	36	60	56	74	T.	−0.1	0	3,763	sw.	19	sw.	29	20	8	2	2.8	0.0	0.0
San Diego	87	62	70	29.84	29.93	+.01	64.3	+0.4	77	24	70	55	12	59	17	59	57	81	T.	0.0	0	3,851	nw.	19	s.	20	12	13	5	4.7	0.0	0.0
San Luis Obispo	201	32	40	29.76	29.98	+.03	63.8	+3.4	100	16	77	44	3	51	51	54	49	70	0.00	−0.1	0	3,218	nw.	16	nw.	9	21	8	1	2.4	0.0	0.0
West Indies.																																
San Juan, P. R.	82	8	54	29.94	30.03	.....	78.4	.....	89	27	83	70	17	74	13	.....	.....	.....	5.15	−0.7	19	9,429	e.	34	e.	30	8	16	6	5.1	0.0	0.0
Panama Canal.																																
Balboa Heights	118	7	97	29.73	29.85	+.01	79.8	−0.2	91	15	86	71	4	74	17	75	74	87	7.92	+0.4	23	3,764	nw.	27	s.	4	0	8	22	8.0	0.0	0.0
Colon	36	7	97	29.81	29.85	+.01	81.0	+0.9	89	30	87	73	4	76	14	76	75	84	8.30	−5.0	24	5,561	se.	25	n.	25	0	8	22	8.0	0.0	0.0
Alaska.																																
Juneau	80	11	54	.....	.....	.....	53.2	.....	75	1	60	42	4	46	29	49	44	72	2.67	.....	12	3,708	s.	24	nw.	18	6	3	21	7.6	0.0	0.0

TABLE 2.—*Data furnished by the Canadian Meteorological Service, June, 1922.*

Stations.	Altitude above mean sea level, Jan. 1, 1919.	Pressure.			Temperature of the air.						Precipitation.		
		Station reduced to mean of 24 hours.	Sea level reduced to mean of 24 hours.	Departure from normal.	Mean max.+mean min.÷2.	Departure from normal.	Mean maximum.	Mean minimum.	Highest.	Lowest.	Total.	Departure from normal.	Total snowfall.
	Feet.	*In.*	*In.*	*In.*	*°F.*	*°F.*	*°F.*	*°F.*	*°F.*	*°F.*	*In.*	*In.*	*In.*
St. Johns, N. F	125												
Sydney, C. B. I	48	30.00	30.05	+.10	57.8	+2.4	68.1	47.5	84	36	3.04	−0.19	0.0
Halifax, N. S	88	29.91	30.01	+.06	60.0	+2.3	68.7	51.2	87	39	3.82	+0.06	0.0
Yarmouth, N. S	65	29.92	29.99	+.04	57.7	+2.7	65.5	50.0	76	41	2.88	+0.12	0.0
Charlottetown, P. E. I	38	29.93	29.97	+.05	62.4	+5.0	70.3	54.5	83	46	5.02	+2.35	0.0
Chatham, N. B	28	29.91	29.94	+.05	63.3	+3.3	73.6	53.0	92	41	6.50	+3.04	0.0
Father Point, Que	20	29.88	29.90	+.03	51.8	−1.2	61.2	42.4	82	36	5.66	+2.68	0.0
Quebec, Que	296	29.60	29.92	.00	63.2	+2.0	72.2	54.3	87	42	7.79	+4.14	0.0
Montreal, Que	187	29.69	29.89	−.05	64.5	−0.4	72.5	56.9	86	43	8.62	+5.09	0.0
Stonecliffe, Ont	489												
Ottawa, Ont	236	29.67	29.93	−.01	65.4	+0.1	75.2	55.7	90	42	4.57	+1.65	0.0
Kingston, Ont	285	29.63	29.94	−.03	63.8	+0.4	70.2	57.4	80	41	4.79	+2.36	0.0
Toronto, Ont	379	29.55	29.94	−.03	66.7	+3.3	77.1	56.3	91	45	4.88	+2.08	0.0
Cochrane, Ont	930												
White River, Ont	1,244	28.62	29.92	−.02	56.4	−2.3	72.9	39.9	90	18	0.76	−1.46	0.0
Port Stanley, Ont	592	29.37	30.01	+.04	64.0	+0.2	73.5	54.6	90	41	2.61	−0.12	0.0
Southampton, Ont	656				60.7	+0.3	81.5	51.3	82	38	3.94	+1.59	0.0
Parry Sound, Ont	688	29.27	29.95	−.01	63.0	+1.3	74.3	51.7	86	37	2.02	−0.40	0.0
Port Arthur, Ont	644	29.24	29.95	+.01	58.2	+1.8	68.3	48.2	87	35	2.45	−0.28	0.0
Winnipeg, Man	760	29.07	29.89	.00	64.6	+2.4	77.8	51.5	96	37	2.28	−1.01	0.0
Minnedosa, Minn	1,690	28.12	29.90	+.02	61.7	+2.1	74.6	48.8	91	35	5.56	+2.56	0.0
Le Pas, Man	860												
Qu'Appelle, Sask	2,115	27.66	29.87	.00	62.0	+2.1	74.6	49.5	88	37	2.93	−0.49	0.0
Medicine Hat, Alb	2,144	27.60	29.81	−.04	68.0	+6.0	82.8	53.3	93	40	2.44	−0.32	0.0
Moose Jaw, Sask	1,759												
Swift Current, Sask	2,392	27.40	29.98	+.11	62.9	+2.9	76.7	49.2	91	37	4.75	+2.08	0.0
Calgary, Alb	3,428	26.43	29.95	+.11	60.7	+4.7	76.2	45.2	90	32	1.90	−0.55	0.0
Banff, Alb	4,521	25.40	29.90	+.06	55.2	+3.7	70.6	39.9	82	31	0.97	−2.36	3.2
Edmonton, Alb	2,150												
Prince Albert, Sask	1,450	28.34	29.90	+.03	60.8	+3.1	73.8	47.8	86	34	2.52	+0.01	0.0
Battleford, Sask	1,592	28.16	29.87	+.01	62.3	+2.8	75.8	48.8	89	33	0.31	−3.00	0.0
Kamloops, B. C	1,262	28.70	29.96	+.09	68.5	+4.7	83.7	53.4	96	42	0.12	−1.30	0.0
Victoria, B. C	230	29.78	30.03	+.02	57.2	+0.9	64.8	49.7	78	45	0.03	−1.17	0.0
Barkerville, B. C	4,180	25.69	29.97	+.10	51.5	+0.8	65.5	37.6	77	27	1.35	−2.13	0.0
LATE REPORTS FOR MAY, 1922.													
Sydney, C. B. I	48	29.92	29.97	.00	46.2	+1.0	55.9	36.6	80	28	2.90	−0.87	
Halifax, N. S	88	29.88	29.99	+.01	50.3	+1.9	60.9	39.8	81	27	4.11	−0.15	
Yarmouth, N. S	65	29.92	29.99	+.01	49.2	+1.6	57.1	41.2	75	32	2.13	−1.67	
Charlottetown, P. E. I	38	29.93	29.97	+.01	48.2	+1.3	56.3	40.1	74	29	2.53	−0.38	
Chatham, N. B	28	29.96	29.99	+.04	51.0	+2.5	61.3	40.8	84	28	2.94	−0.27	
Banff, Alb	4,521	25.35	29.90	+.02	46.3	−0.7	59.6	33.1	79	26	0.68	−1.36	1.8
Kamloops, B. C	1,262	28.75	30.04	+.15	56.8	−2.3	69.8	43.8	90	34	0.19	−1.05	
Medicine Hat, Alb	2,144	27.60	29.85	−.04	55.7	+1.6	68.1	43.4	95	32	1.38	+0.07	
Barkerville, B. C	4,180	25.64	29.94	+.10	41.1	−4.4	51.9	30.3	75	21	3.31	+0.79	23.3
Calgary, Alb	3,428	26.38	29.90	+.02	51.3	+2.3	67.8	34.9	83	26	0.41	−1.36	0.0

SEISMOLOGICAL REPORTS FOR JUNE, 1922.

W. J. HUMPHREYS, Professor in Charge.

[Weather Bureau, Washington, August 3, 1922.]

TABLE 1.—*Noninstrumental earthquake reports, June, 1922.*

Day.	Approximate time, Greenwich civil.	Station.	Approximate latitude.	Approximate longitude.	Intensity Rossi-Forel.	Number of shocks.	Duration.	Sounds.	Remarks.	Observer.
1921.	*H. m.*	ARIZONA.	° ′	° ′			*Sec.*			
June 15	13 40	Yuma	32 40	114 35	4	1	Short.	None	Felt by many	J. H. Gordon.
	15 20	....do	32 40	114 35	3	1	Short.	....do	....do	Do.
	21 01	....do	32 40	114 35	5	4	20, 15	....do	Felt by everyone	Do.
		CALIFORNIA.								
10	14 55	Hollister	36 45	121 20	4	1		....do	Felt by many	J. Patterson.
	15 05	Salinas	36 41	121 39	3	1	Brief.	....do	....do	Dr. E. D. Eddy.
	20 03	....do	36 41	121 39	3	1	Brief.	....do	Felt by few	Do.
	20 10	Hollister	36 45	121 20	4			....do	Felt by many	J. Patterson.
15	13 35	Calexico	32 41	115 30	2	1	5	....do	Felt by several	R. F. Seifert.
	15 30	....do	32 41	115 30	2	1	10	....do	....do	W. S. Pratt.
16	19 43	....do	32 41	115 30	3	1	3	....do	....do	Do.
	21 00	Amos	33 05	115 16	5	2	3ca.	Faint	Felt by many	R. H. Freeman.
		Calexico	32 41	115 30	4	2	35, 2	None	....do	W. S. Pratt.
		WASHINGTON.								
1	23 27	Spokane	47 40	117 30	4	1	4	Loud	....do	F. B. Meikle.
	23 30	....do	47 40	117 30	2			None		F. B. Whitney.
		....do	47 40	117 30				Faint	Walls cracked	Mrs. A. E. Abbott.
	23 35	....do	47 40	117 30		1	20	Rumbling	Felt by several	H. J. Cole.

TABLE 2.—*Instrumental seismological reports, June, 1922.*

Time used: Mean Greenwich, midnight to midnight. Nomenclature: International.

For significance of symbols and description of stations, see REVIEW for January, 1922.

ARIZONA. *U. S. C. & G. S. Magnetic Observatory, Tucson.*

Date.	Character.	Phase.	Time.	Period T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
1922.			*H. m. s.*	*Sec.*	μ	μ	*Km.*	
June 12	....	*O*.....	4 47 08	......	......	......	1,210	Recorded on magnetograph, from 4:51 to 5:01.
		P.....	4 49 46	4	......	......	......	
		S_N....	4 51 55	6	......	......	......	
		L1....	4 52 08	30	......	......	......	
		$L2_N$...	4 52 34	20	......	......	......	
		M_E....	4 54 47	8	760	......	......	
		M_N....	4 53 37	8	......	500	......	
		C_E....	4 57 ..	......	......	......	......	
		C_N....	4 56 ..	......	......	......	......	
		F_E....	5 51 ..	......	......	......	......	
		F_N....	5 50 ..	......	......	......	......	
12	....	P_N....	10 45 54	......	......	......	......	
		e......	10 47 14	......	......	......	......	
		S_E....	10 48 46	......	......	......	......	
		L_E....	10 49 19	10	......	......	......	
		L_N....	10 49 56	......	......	......	......	
		M_E....	10 51 05	8	155	......	......	
		M_N....	10 51 41	8	......	57	......	
		F_E....	11 18 ..	......	......	......	......	
		F_N....	11 10 ..	......	......	......	......	
16	....	*O*.....	20 59 20	......	......	......	500?	Recorded on magnetograph at 21:02.
		P_E....	21 00 16	......	......	......	......	
		P_N....	21 00 26	......	......	......	......	
		S_N....	21 00 54	......	......	......	......	
		L1....	21 01 09	......	......	......	......	
		$L2_E$...	21 01 32	......	......	......	......	
		M_E....	21 01 45	3	380	......	......	
		M_N....	21 01 22	4	......	420	......	
		F_N....	21 21 ..	......	......	......	......	
17	....	P.....	23 44 56	......	......	......	......	Local tremor; no definite M on N.
		iL....	23 45 02	......	......	......	......	
		M_E....	23 45 08	2	47	......	......	
		F_E...	23 46 51	......	......	......	......	
		F_N....	23 50 ..	......	......	......	......	

CALIFORNIA. *Theosophical University, Point Loma.*

Date.	Character.	Phase.	Time.	Period T.	A_E	A_N	Distance.	Remarks.
1922.			*H. m. s.*	*Sec.*	μ	μ	*Km.*	
June 13	....	....	....	......	100	150	......	Tremors during preceding 24 hours.
14	....	....	....	......	100	100	......	
30	....	....	....	......	50	50	......	

COLORADO. *Regis College, Denver.*

Date.	Character.	Phase.	Time.	Period T.	A_E	A_N	Distance.	Remarks.
1922.			*H. m. s.*	*Sec.*	μ	μ	*Km.*	
June 12	....	P.....	4 49 30	......	......	......	......	
		S_E....	4 51 30	......	......	......	......	
		L_N....	4 54 ..	......	......	*5,000	......	
		L_E....	4 53 ..	......	*9,000	......	......	
		M_N....	?........	6.6	......	*5,000	......	
		M_E....	?........	8.5	*9,000	......	......	
		C_N....	5 04 ..	......	......	......	......	
		C_E....	5 00 ..	......	......	......	......	
		F.....	5 13 ..	......	......	......	......	
12	....	L_N....	10 48 ..	10	......	*1,500	......	Sinusoidal on EW; irregular on NS.
		L_E....	10 48 ..	10	*1,000	......	......	
		F.....	10 55 ..	......	......	......	......	
16	....	P.....	21 01 ..	......	......	......	......	No S visible.
		L_N....	21 03 ..	8	......	*5,000	......	
		L_E....	21 03 ..	8	*4,000	......	......	
		F.....	21 07 ..	......	......	......	......	

DISTRICT OF COLUMBIA. *U. S. Weather Bureau, Washington.*

Date.	Character.	Phase.	Time.	Period T.	A_E	A_N	Distance.	Remarks.
1922.			*H. m. s.*	*Sec.*	μ	μ	*Km.*	
June 2	....	P?....	20 31 40	......	......	......	......	Very feeble.
		S?....	20 41 14	......	......	......	......	
		F.....	20 45 ..	......	......	......	......	
12	....	P.....	4 53 52	......	......	......	3,400	L not discernible.
		S.....	4 59 00	......	......	......	......	
		M.....	4 55 ..	......	*17,000	......	......	
		F.....	6 *ca.*	......	......	......	......	
12	....	P.....	10 49 52	......	......	......	2,800	Do.
		S.....	10 54 26	......	......	......	......	
		F.....	11 40 *ca.*	......	......	......	......	
16	....	e.....	21 11 46	......	......	......	......	
		L?....	21 16 25	......	......	......	......	
		F.....	21 35 *ca.*	......	......	......	......	
27	....	e.....	14 52 05	......	......	......	......	
		F.....	15 *ca.*	......	......	......	......	

*Trace amplitude.

HAWAII. *U. S. C. & G. S. Magnetic Observatory, Honolulu.*

Date.	Character.	Phase.	Time.	Period T.	A_E	A_N	Distance.	Remarks.
1922.			*H. m. s.*	*Sec.*	μ	μ	*Km.*	
June 2	....	*O*.....	20 10 38	......	......	......	9,600	No definite L nor M on N.
		P_E....	20 23 20	......	......	......	......	
		P_N....	20 23 32	......	......	......	......	
		S_E....	20 34 00	......	......	......	......	
		S_N....	20 33 56	......	......	......	......	
		$SR1_N$.	20 40 00	......	......	......	......	
		$SR2_N$.	20 44 10	......	......	......	......	
		L_E....	20 51 05	......	......	......	......	
		M_E....	20 54 28	16	26	......	......	
		F_E....	21 27 —	......	......	......	......	
		F_N....	21 29 —	......	......	......	......	
12	....	*O*.....	4 47 30	......	......	......	5,080	eP indicated only by irregularity in microseisms; i_E may be SR2.
		eP_E...	4 57 20	......	......	......	......	
		S_E....	5 02 55	......	......	......	......	
		S_N....	5 02 50	......	......	......	......	
		$SR1_N$.	5 06 08	20	......	......	......	
		i_E....	5 07 55	22	......	......	......	
		eL_E...	5 12 07	9	......	......	......	
		iL_N...	5 10 08	9	......	......	......	
		M_E....	5 14 30	8	40	......	......	
		M_N....	5 14 11	7	......	52	......	
		F_E....	6 46 —	......	......	......	......	
		F_N....	6 55 —	......	......	......	......	
12	....	e_E....	10 57 57	......	......	......	......	
		e_N....	10 58 10	......	......	......	......	
		e_E....	11 02 40	......	......	......	......	
		e_N....	11 02 18	......	......	......	......	
		L_E....	11 03 50	......	......	......	......	
		L_N....	11 04 07	......	......	......	......	
		M_E....	11 05 45	8	45	......	......	
		M_N....	11 05 10	8	......	55	......	
		F_E....	12 11 —	......	......	......	......	
		F_N....	12 18 —	......	......	......	......	
12	....	e_N....	14 14 —	18	......	......	......	Very slight; no record on E.
		F_N....	14 28 —	......	......	......	......	
16	....	*O*.....	20 59 05	......	......	......	3,960	
		P_N....	21 06 20	......	......	......	......	
		e_E....	21 16 18	......	......	......	......	
		L_E....	21 17 38	10	......	......	......	
		L_N....	21 16 28	12	......	......	......	
		M_E....	21 21 34	9	14	......	......	
		M_N....	21 21 02	8	......	14	......	
		F_E....	21 34 ..	......	......	......	......	
		F_N....	21 28 ..	......	......	......	......	
21	....	e.....	13 23 05	13	3	......	......	Very slight.
		F_E....	13 24 ..	......	......	......	......	
		F_N....	13 29 ..	......	......	......	......	
22	....	L_E....	20 25 17	17	......	......	......	
		L_N....	20 25 30	......	......	......	......	
		M_E....	20 26 00	12	7	......	......	
		M_N....	20 26 32	......	......	3	......	
		F_E....	20 59 ..	......	......	......	......	
		F_N....	20 52 ..	......	......	......	......	
27	....	*O*.....	14 29 54	......	......	......	8,100	N record very slight.
		P.....	14 41 20	......	......	......	......	
		S_E....	14 50 45	......	......	......	......	
		eS_N...	14 51 45	......	......	......	......	
		$L1_E$....	15 03 30	25	......	......	......	
		$L2_E$...	15 06 00	19	......	......	......	
		M_E....	15 15 18	17	16	......	......	
		F_E....	15 54 ..	......	......	......	......	
		F_N....	15 25 ..	......	......	......	......	

Period of pendulums, 12 sec.; multiplication, 150; sensitivity before June 14, N., 28.6; E., 24.4; after June 14, N., 28.6; E., 25.7.

ILLINOIS. *U. S. Weather Bureau, Chicago.*

Date.	Character.	Phase.	Time.	Period T.	A_E	A_N	Distance.	Remarks.
1922			*H. m. s.*	*Sec.*	μ	μ	*Km.*	
June 2	....	P.....	20 31 44	......	......	......	8,800	
		S.....	20 41 46	......	......	......	......	
		eL....	21 01 20	......	......	......	......	
		L.....	21 18 ..	18	......	......	......	
		L.....	21 38 ..	16	......	......	......	
		F.....	23 20 ..	......	......	......	......	
3	....	e.....	1 49 26	......	......	......	......	
		F.....	2 *ca.*	......	......	......	......	
5	....	e.....	4 43 30	......	......	......	......	
		L.....	5 11 ..	22	......	......	......	
		F.....	5 30 ..	......	......	......	......	
8	....	e.....	11 07 30	......	......	......	......	
		L.....	11 25 ..	......	......	......	......	

ILLINOIS. *United States Weather Bureau, Chicago*—Continued.

1922.			*H. m. s.*	*Sec.*	μ	μ	*Km.*	
12		P	4 53 03				2,800	
		S	4 57 33					
		L	4 59 48					
		M_E	5 01 30		*34,500			
		F	7 30 *ca.*					
12		P	10 48 33				2,800	
		S	10 53 05					
		L	10 55 13					
		M_E	10 58 20		*7,000			
		F	13 *ca.*					
15		e	15 41 48					
		F	16 10 *ca.*					Quake between 21*h.* and 22*h.* impossible to decipher because of tangling.
16								
27		P	14 50 19				8,400	
		S?	15 00 00					
		L	15 33 ..	22				
		L	15 54 ..	15				
		F	17 20 *ca.*					

MARYLAND. *U. S. C. & G. S. Magnetic Observatory, Cheltenham.*

1922.			*H. m. s.*	*Sec.*	μ	μ	*Km.*	
June 12		*O*	4 47 14				3,500	Times on N doubtful; marker not operating.
		S_E	4 59 11					
		S_N	4 58 43					
		$SR1_E$	5 00 41					
		$SR1_N$	5 00 26	11				
		$L1_N$	5 01 51	40				
		L_E	5 04 18					
		$L2_N$	5 03 32					
		M_E	5 07 18	13	410			
		M_N	5 04 52	15		1,150		
		C_N	5 06 ..					
		F_E	5 40 ..					
		F_N	5 29 ..					
12		e_E	11 04 29					
		e_N	10 57 19	6				
		L_N	11 00 15					
		M_N	11 01 27	12		50		
		F_E	11 16 ..					
		F_N	11 14 ..					
16		O	20 59 07				3,840	
		S_N	21 11 51					
		$L1_N$	21 15 56					
		$L2_N$	21 16 36					
		M_N	21 17 29	8		14		
		F_N	21 24 ..					

MISSOURI. *St. Louis University, St. Louis.*

1922.			*H. m. s.*	*Sec.*	μ	μ	*Km.*	
May 12		eL_E	19 35 18					Sinusoidal.
		M_E	19 39 30	24	*2,000			
		F	19 50 —					
June 12		iP	4 52 36				2,400	
		iS	4 56 30					
		eL	4 57 30					
		M	4 59 30	6	*18,000	*21,000		
		M_E	5 00 54	9	*18,000			
		M_N	5 00 54	12		*19,000		
		F	5 47 —					
12		eP	10 48 00				2,700	
		eS	10 52 20					
		L	10 53 30					
		M_N	10 56 42	12		*3,000		
		M_E	10 57 —	12	*4,000			
		F	11 11 —					
16		iP	21 04 12				3,100	
		S	21 09 00					
		L	21 10 30					
		F	21 30 —					

NEW YORK. *Fordham University, New York.*

1922.			*H. m. s.*	*Sec.*	μ	μ	*Km.*	
June 12		eP_E	4 54 17				3,900	P obscured by locals.
		eS_E	4 59 48					
		eS_N	4 59 48					
		L_E	5 04 *ca*					
		M_E	5 07 53					
12		$P?_N$	11 55 17					
		$P?_E$	11 55 22					
		L_N	12 02 *ca*					
16		e	21 15 36					
		L_E	21 17 *ca*					

* Trace amplitude.

CANAL ZONE. *Panama Canal, Balboa Heights.*

1922.			*H. m. s.*	*Sec.*	μ	μ	*Km.*	
June 12		P_E	4 54 55				4400*ca*	Direction unknown.
		P_N	4 54 45					
		S_N	5 00 55					
		L_E	5 03 00					
		L_N	5 03 05					
		M_E	5 07 15		*500			
		M_N	5 04 55			*500		
		F_E	5 25 00					
		F_N	5 29 00					
25		P_E	11 16 28				300*ca*	Probably to the SW.
		P_N	11 16 22					
		S_E	11 17 00					
		S_N	11 16 54					
		M_E	11 17 02		*1,800			
		M_N	11 17 20			*1,800		
		F_E	11 20 15					
		F_N	11 22 00					

PORTO RICO. *U. S. C. & G. S. Magnetic Observatory, Vieques.*

1922.			*H. m. s.*	*Sec.*	μ	μ	*Km.*	
June 12		O	4 47 15				4,520	
		P_E	4 55 10	6				
		$PR1_E$	4 56 44					
		$PR1_N$	4 56 33					
		S	5 01 26					
		$L1_E$	5 06 27	43				
		$L2_E$	5 08 05	29				
		eL_N	5 13 17					
		M_E	5 09 42	24	40			
		M_N	5 15 47	17		10		
		F_E	5 27 ..					
		F_N	5 22 ..					
16		i	20 10 17					Felt in Vieques; recorded on H variometer at 20:10.
		M	20 10 22	2	88	64		
		F_E	20 11 41					
		F_N	20 12 50					

VERMONT. *U. S. Weather Bureau, Northfield.*

1922.			*H. m. s.*	*Sec.*	μ	μ	*Km.*	
June 12		e	4 53 30					Phases indistinguishable.
		M	5 07 30		*12,000			
		F	5 35 *ca*					
12		e	10 59 ..					
		F	11 20 *ca*					
16		e	21 17 ..					
		F	21 25 *ca*					

CANADA. *Dominion Observatory, Ottawa.*

1922.			*H. m. s.*	*Sec.*	μ	μ	*Km.*	
June 2		i	20 32 24					Well marked as reported, but phases do not fit into any certain epicentre determination.
		e_M	20 43 00					
		e_M	20 50 32					
		$eL?_{ME}$	21 07 ..					
		L_{ME}	21 20 ..	19				
		L	21 25 *to*					Subscript M denotes Milne-Shaw record.
			21 39 ..	19				
		L_M	21 46 ..	15				
		L	21 53 42	15				
		F	23 *ca.*					
3		e_M	1 54 ..					No trace on other instruments.
		F	2 01 *ca.*					
3		eL_M	5 48 ..					Do.
		L_M	5 55 ..					
		L_M	6 00 ..					
		F	6 12 *ca.*					
4		e_M	21 37 ..					Do.
		eL	21 40 30	17				
		L	21 49 ..	24				
		F	21 56 *ca.*					
8		e_E	11 05 48					Milne-Shaw not recording.
		e	11 06 50					
		F	11 18 ..					
12		O	4 47 27				3,750	Do. Periods very irregular and difficult to determine.
		P	4 54 26					
		S	4 59 59					
		eL	5 04 ..					
		M	5 06 26					
		F	6 10 ..					
12		e_E	10 49 36					Milne-Shaw not recording.
		i	10 55 37					
		i	11 00 04					
		eL	11 02 ..					
		L	11 03 *to*					
			11 10 ..	8				
		F	12 10 ..					

* Trace amplitude.

CANADA. *Dominion Observatory, Ottawa.*

1922.			H. m. s.	Sec.	μ	μ	Km.	
16		e_M	11 02 30					
		e_M	11 08 24					
			to 13 ..					
		L?	11 55 *to*					
			12 02 ..	8				
		F	12 10 ..					
16		eL	12 55 *to*					
			12 58 ..	6				
16		e	21 11 07					
		i	21 14 00					
		eL	21 16 ..					
		M	21 17 ..					Irregular period in maximum phase.
		F	22 20 ..					
27		i	14 50 30					Milne-Shaw shows an indication of LR1 at 16:37, but it does not show very definitely, and if correctly placed does not help in determination of epicentre.
		e	15 00 40					
		eL	15 27 30					
		L	15 39 ..	23				
		L	15 49 *to*					
			16 04 ..	19				
		F	17 *ca.*					

CANADA. *Dominion Meteorological Service, Toronto.*

1922.			H.m.s.	Sec.	μ	μ	Km.	
June 2		L?	20 52 36					Heavy micros going on.
		L	21 06 54					
		L	21 27 12					
			to 54 06		*300			
12		P	4 54 42				3,330	P not well defined.
		S	4 59 48					
		iL	5 04 24					
		M	5 05 06		*9,000			
		eL	5 22 30					
		eL	5 41 48					
		F	6 11 12					
			?6 34 48					
12		e	?10 50 30					
		eL	10 55 06					
		iL	11 01 36					
		M	11 02 06		*500			
		F						Micros.
16		L	16 11 24					Micros interfere with phases.
		M	16 17 06		*200			
		F						Micros.
27		i	14 52 18					Marked micros render readings doubtful.
		i	?14 59 06					
		e	15 02 24					
		L	15 41 36		*200			
		F						Micros.

CANADA. *Dominion Meteorological Service, Victoria.*

1922.			H.m.s.	Sec.	μ	μ	Km.
June 2		P?	21 38 11				
		L	21 56 11				
		M	22 02 38		*500		
		F	22 38 20				
16		P	21 06 21				520
		L	21 07 31				
		M	21 10 39		*1,000		
		F	21 22 43				
27		e?	14 56 18				
		e?	15 01 30				
		L?	15 11 36				
		eL	15 17 30				
		M	15 20 42		*400		
		F	15 45 00				

VERTICAL SEISMOGRAPH.

12		P	4 54 00	2			
		L	5 05 20	7			
		M	5 08 45	7		4	
12		L	10 02 00	15			
		M	10 04 45	12		5	
		F	10 14 00				

* Trace amplitude.

No earthquakes were recorded at the following stations during June, 1922:

ALASKA. *U. S. C. & G. S. Magnetic Observatory*, Sitka.

Reports for June, 1922, have not been received from the following stations:

ALABAMA. *Spring Hill College*, Mobile.

DISTRICT OF COLUMBIA. *Georgetown University*, Washington.

MASSACHUSETTS. *Harvard University*, Cambridge.

NEW YORK. *Cornell University*, Ithaca.

TABLE 3.—*Late reports (instrumental).*

DISTRICT OF COLUMBIA. *Georgetown University, Washington.*

1922.			H. m. s.	Sec.	μ	μ	Km.	
Apr. 2		e	17 08 ..					Very difficult; very heavy micros.
		eL	17 17 ..					
		F	17 40 ..					
2		eP_E?	19 26 04					Very heavy micors.
		eP_N	19 26 47					
		S_E	19 36 06					
		eL_E	19 47 42	16				
		eL_N	19 47 42	16				
		L_E	18 52 ..	21				
		F	20 40 ..					
5		e_E	3 29 52					Very heavy micros.
		e_N	3 30 ..					
		F						Micros.
8		eP	20 51 ..					
		eS_E	20 58 00					
		eS_N	20 58 04					
		eL_E	21 04 24					
		eL_N?	21 04 24					
		L_E	21 08 ..	16				
		L_N	21 08 09	16				
		F	22 *ca.*					
11		eL	1 20 25					
		L_E	1 22 10	21				
		L_N	1 23 20	20				
		F	1 40 ..					
13		eP_E	15 20 22					Difficult.
		eP_N	15 20 19					
		eS_E?	15 24 37					
		eS_E?	15 24 33					
		F	15 50 ..					
25		L_E	22 22 ..	22				
		L_N	22 24 ..	22				
		L_E	22 45 ..	21				
		F	24 *ca.*					
26		e	4 14 24					
		S_E?	·4 22 06					
		eL_E?	4 28 06	15				
		F	5 20 ..					

ARIZONA. *U. S. C. & G. S. Magnetic Observatory, Tucson.*

1922.			H. m. s.	Sec.	μ	μ	Km.	
May 12		L_E	19 23 00	18				No record on N.
		M_E	19 30 13		40			
		C_E	19 33 05					
		F_E	19 45 ..					

PORTO RICO. *U. S. C. & G. S. Magnetic Observatory, Vieques.*

1922.			H. m. s.	Sec.	μ	μ	Km.	
May 2		e	20 24 30					Local shock, recorded on H variometer at 20*h*. 24*m*.
		M	20 24 34		200	90		
		C_E	20 24 47					
		C_N	20 24 39					
		F_E	20 25 27					
		F_N	20 25 41					
11		P	6 47 38	2				No definite maximum on N.
		e_E	6 49 34					
		e_N	6 49 14					
		L_E	6 50 57					
		L_N	6 50 10	9				
		M_E	6 57 56	11	20			
		F_E	7 05 ..					
		F_N	7 01 ..					

No earthquakes were recorded during May, 1922, at the C. & G. S. Magnetic Observatories at Cheltenham, Md., and at Sitka, Alaska.

CANADA. *Dominion Meteorological Service, Toronto.*

1922.			*H., m. s.*	*Sec.*	*μ*	*μ*	*Km.*	
May 2		L	13 11 42?					Micros going on.
		L	13 16 24		*200			
4		e	9 30 48					First phases indistinct.
		S?	9 34 30					
		eL	9 59 30					
		eL	10 01 18					
		M	10 08 24		*1,300			
		F	12 25 18					
9		L	14 07 42					
		F			*100			
11		eL	1 18 54					
		F	1 24 18		*200			
11		L	10 21 00					
		eL	10 26 54					
		M	10 28 54		*200			
		F						Micros.
12		i	19 05 54					Quake came from the west.
		e	19 09 36					
		i	19 21 54					
		eL	19 41 54					
		eL	19 46 00					
		M	19 49 54		*5,000			
		iL	20 01 06					
		L	20 13 12					
		L	20 54 24					
		L	20 57 36					
		eL	21 05 12					
22		L	18 15 48		*100			Small micros going on.

CANADA. *Dominion Meteorological Service, Victoria.*

1922.			*H. m. s.*	*Sec.*	*μ*	*μ*	*Km.*	
May 2		L	13 07 29					
		M	13 12 54		*350			
		F	13 30 36					
4		L	10 28 30					
		M	10 42 53		*500			
		F	11 48 20					
9		L?	14 04 24					
		M	14 08 22		*200			
		F	14 14 19					
9		L?	14 46 03					
		M	14 52 00		*200			
11		L	7 04 06					
		M						Slipped.
11		M	10 01 37		*100			
12		S	19 02 52					
		L	19 09 09					
		M	19 28 10		*800			
		L	20 55 54					
		L	21 01 54					
		F	21 12 18					
22		L	17 45 16					
		M	17 48 14		*100			
		F	17 51 43					

* Trace amplitude.

HAWAII. *U. S. C. & G. S. Magnetic Observatory, Honolulu.*

1922.			*H. m. s.*	*Sec.*	*μ*	*μ*	*Km.*	
May 3		L	4 14 00					
		M	4 14 50	14	*1,200	*800		
		F_N	5 14 ..					
		F_E	4 54 ..					
4		P	9 21 20	6			5,100	L masked by preliminary tremors.
		PR1	9 23 23					
		S	9 28 08	10				
		$SR1_N$	9 31 30					
		$SR2_E$	9 32 35					
		$SR2_N$	9 33 05					
		M_E	9 38 16		*4,000			
		M_N	9 34 58			*3,400		
		F_E	11 30 ..					
		F_N	11 35 ..					
11		e_E	9 32 17					e_N may not be seismic.
		e_N	9 30 36					
		L_E	9 37 ..					
		L_N	9 37 38					
		M_E	9 52 12	15	*900			
		M_N	9 50 43	14		*1,400		
		F_E	10 29 ..					
		F_N	10 21 ..					
12		iP_N	18 48 54				6,120	On E the lines overlapped and obscured the record.
		iS_N	18 56 37	14				
		e_N	19 02 44	14				
		e_N	19 04 37	22				
		M_N	19 07 22	23		*2,200		
		F_N	20 05 ..					
14		e_E	16 10 30					Barely perceptible.
		e_N	16 09 55					
		F_E	16 16 ..					
		F_N	16 22 ..					
23		eP_E	3 24 09					P doubtful; activity on E at 3*h.* 20*m.* 17*s.*; ground movement, E, 121 μ, N, 97 μ; recorded on D and H variometers, from 3:24 to 3:27.
		eP_N	3 23 23					
		L_E	3 25 35					
		L_N	3 25 00					
		M	3 25 55	5	*18,000	*14,500		
		C	3 29 ..					
		F_E	4 05 ..					
		F_N	3 49 ..					
24		e	8 22 23					Barely perceptible.
		F_E	8 25 23					
		F_N	8 26 23					
26		P	9 07 52					
		L	9 08 38	8	*2,500	*2,000		
		F	9 11 28					

* Trace amplitude.

Chart I. Tracks of Centers of Anticyclones, June, 1922. (Inset) Departure of Monthly Mean Pressure from Normal.

Chart I. Tracks of Centers of Anticyclones, June, 1922. (Inset) Departure of Monthly Mean Pressure from Normal.
(Plotted by Wilfred P. Day.)

Chart II. Tracks of Centers of Cyclones, June, 1922. (Inset) Change in Mean Pressure from Preceding Month.
(Plotted by Wilfred P. Day.)

Chart III. Departure (°F.) of the Mean Temperature from the Normal, June, 1922.

Chart IV. Total Precipitation, Inches, June, 1922. (Inset) Departure of Precipitation from Normal.

Chart V. Percentage of Clear Sky between Sunrise and Sunset, June, 1922.

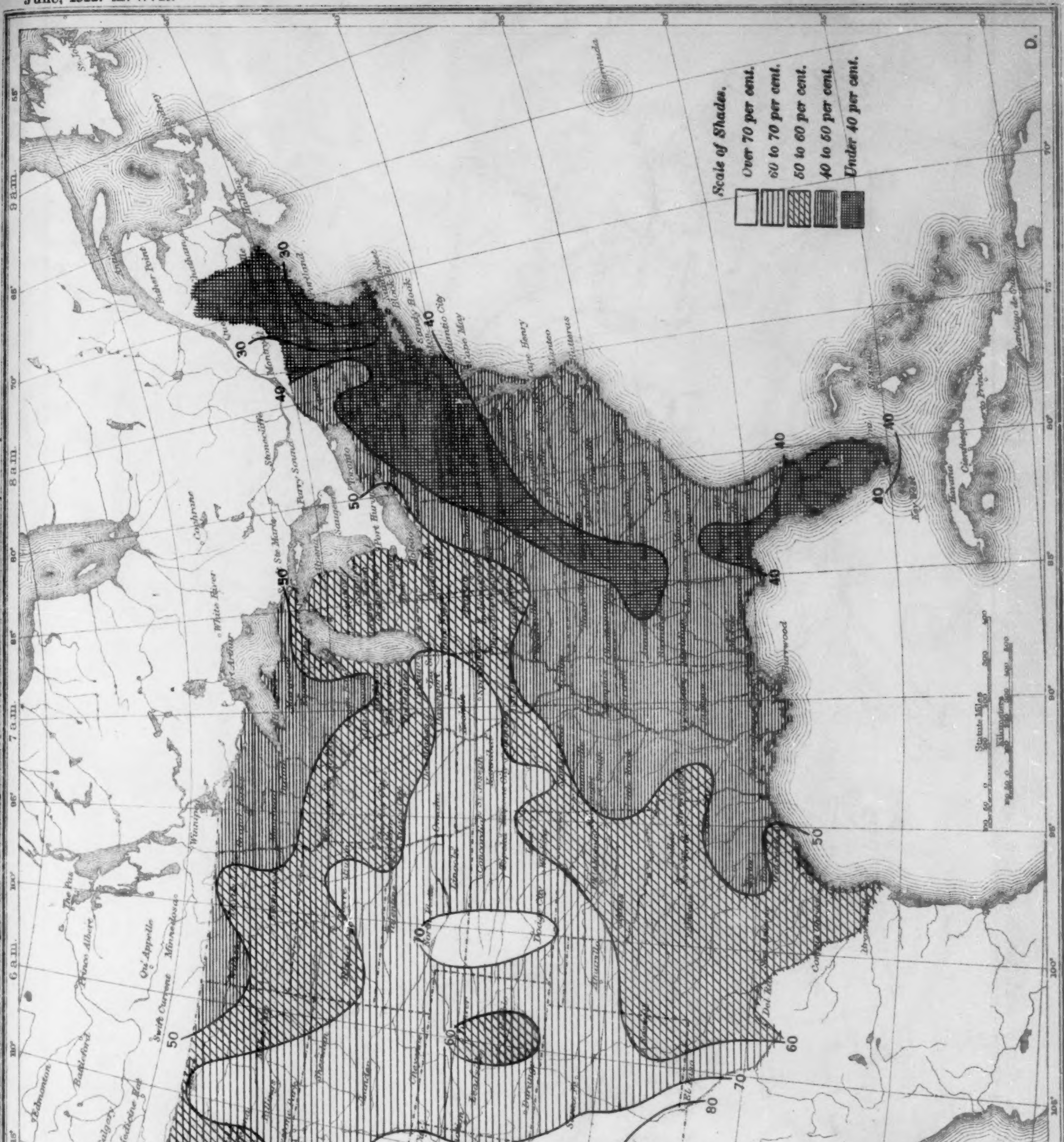
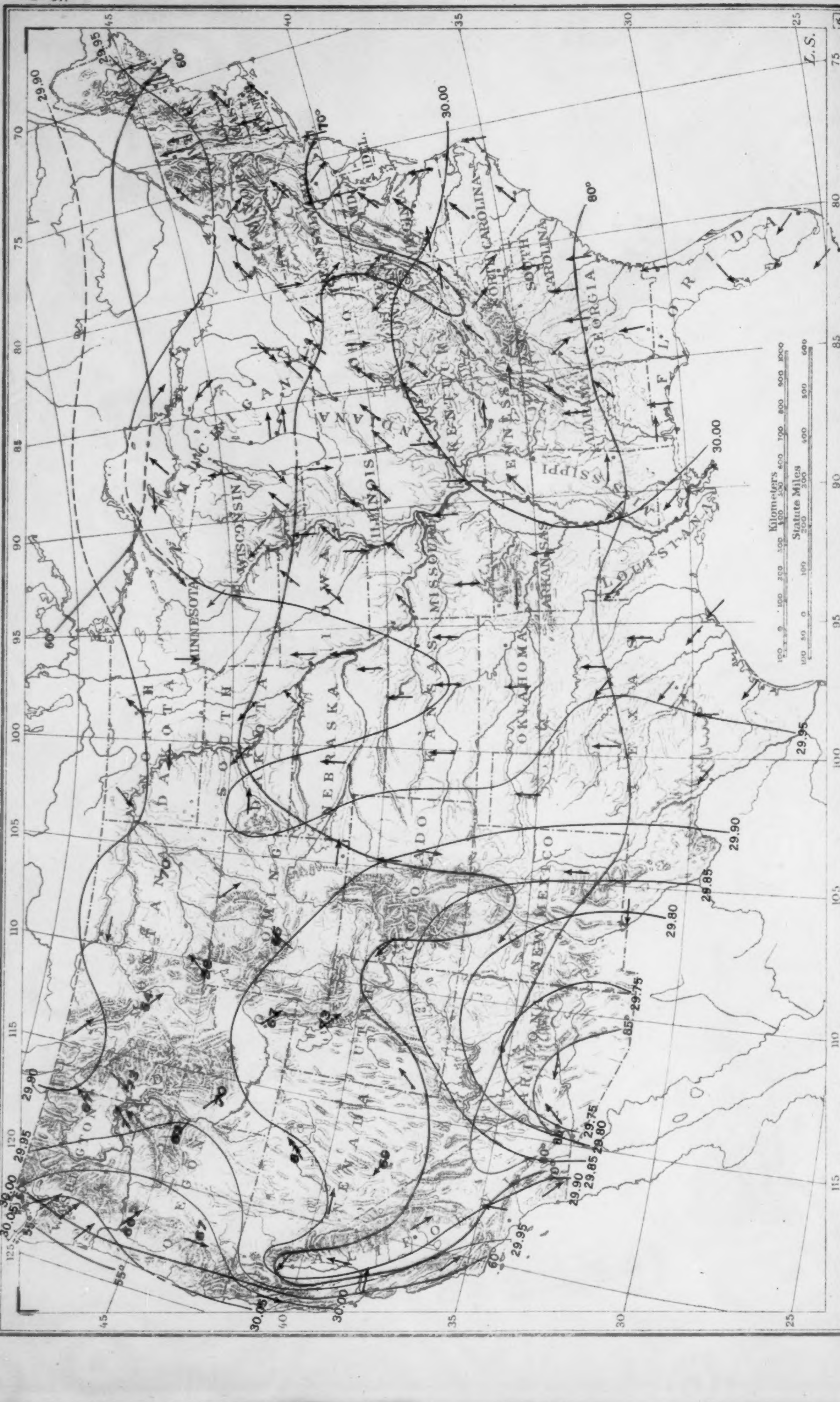


Chart VI. Isobars at Sea-level and Isotherms at Surface; Prevailing Winds, June, 1922.



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JUNE, 1922.

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† In marine separate.